REPLACEMENT FACILITY FOR ROCK CREEK SCHOOL

55B West Frederick Street
Walkersville, Maryland 21793

Bid Set
July 1, 2019

VOLUME 3
Project No: 17-22
FCPS Bid #19C14

Proffitt & Assoc.
ARCHITECTS

BID SET SPECIFICATIONS

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New Facility for
Rock Creek School
Frederick County Public Schools
55B West Frederick St.
Walkersville, Maryland 21793

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SECTION 210500
COMMON WORK RESULTS FOR FIRE SUPPRESSION

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. Piping materials and installation instructions common to most piping systems.
2. Mechanical sleeve seals.
3. Sleeves.
4. Escutcheons.
5. Grout.
6. Equipment installation requirements common to equipment sections.
7. Painting and finishing.
8. Concrete bases.
9. Supports and anchorages.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all fire suppression work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with "Submittals" specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 21 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Mechanical sleeve seals.
2. Escutcheons.

B. Welding certificates.

C. LEED Submittals: Comply with Section 08113
1. EQ Credit 2: Low-Emitting materials
   a. For interior wet applied welding cements, adhesives, sealants, paints, coatings: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method V1.1-2010 and VOC content in g/l. Include volume of material applied per product.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations. Coordinate the work under Division 21 with the work of all other construction trades. Conform to the requirements of all rules, regulations, and Codes of local, State and Federal Authorities Having Jurisdiction.

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

C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in this Division.

D. Coordinate location, installation and integration of fire protection devices with the fire alarm system for a fully turnkey installation.

1.8 DESCRIPTION:

A. Layout sprinkler system complete and size all fire protection piping in accordance with requirements of the National Fire Protection Association, Frederick County/Local Fire Department and State Fire Marshal. System shall be designed for occupancy as required by applicable codes. Conceal fire protection piping in finished spaces unless indicated otherwise. System drains and inspector's test shall not be located in finished spaces.

B. Sprinkler equipment and work shall conform to requirements of National Fire Protection Association Standard NO. 13. In addition, all work shall conform to the latest requirements of all Codes and regulations of Authorities Having Jurisdiction over this work, including, but not limited to, State Fire Marshal, Frederick County/Local Fire Department, Safety Codes, International Building Codes and ANSI Elevator and Escalator Code.

C. Preliminary Shop Drawing: Prior to preparing detailed working drawings for submission to State Fire Marshal, submit preliminary sprinkler system layout to the Architect for review and approval. Show all finished ceilings, light fixtures, air diffusers, and other ceiling-mounted devices. Coordinate sprinkler head types and locations with ceiling types. All sprinkler heads in occupied areas shall be concealed with flush cover plate.

D. The Fire Protection Contractor shall prepare dimensioned and detailed working drawings, specification, and hydraulic calculations and submit same to the State Fire Marshal for review and approval. The Fire Protection Contractor shall have hydraulic calculations, dimensioned working drawings, and specifications signed and sealed by a registered Fire Protection Engineer prior to the submittal review process. One set of these approved documents shall be provided each, to the Engineer, Architect, and Owner for record purposes. All costs related to changes required to obtain the Fire Marshal's approval shall be the responsibility of the Contractor.

E. Manufactured equipment and materials shall be submitted to the Engineer for review and approval.

F. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all fire protection work.

G. The fire protection contractor shall perform a fire flow test for the design of the fire protection system within 30 days of contract approval. The sprinkler contractor base their bid on not having a fire pump and the add alternate #9 bid is based on having a fire pump. Within 60 days of contract approval the fire protection contractor shall submit preliminary calculations based on their flow test. The Owner shall determine if the fire pump shall be provided based on these results.

1.9 PERMITS AND FEES

A. Obtain all permits and pay taxes, fees, and other costs in connection with the work. File necessary plans, prepare documents, give proper notices, and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the General Requirements of the specification.

1.10 EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for Contractor's failure to do so.

1.11 CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Fire Suppression Divisions shall be fully qualified and acceptable to the Architect. Submit the following evidence, if requested.
   1. A list of not less than five comparable projects that the contractor completed.
   2. Letter of reference form not less than three registered professional engineers, Contractors or building owners.
   3. Local and/or State License, where required.
   4. Membership in trade or professional organizations where required.
   5. The contractor shall be licensed to certify the calculations and design.

B. A Contractor is any individual, partnership, or corporation, performing work by Contract or subcontract on this project.

C. Acceptance of a Contractor of Subcontractor will not relive the contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work of various trades.

1.12 MATERIALS AND EQUIPMENT:

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. This Contractor shall be responsible for connection all utilities as shown on the drawings to equipment identified as "under another Division".

B. Where material or equipment is identified by proprietary name, model number, and/or manufacturer, furnish named item, or its equal only of other manufacturers who are indicated in this specification, subject to approval by the Engineer, Architect and the Owner. Alternate manufacturers or items other than the first-named shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Alternate manufacturers/items are items other than first named, which shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Manufacturers not named are not acceptable and shall not be submitted.

D. Substitution will not be permitted for specified items of material or equipment where only one manufacturer is identified.

E. The Contractor shall only submit those manufacturers indicated in the specification. Proposed alternate manufacturers must be approved by the Owner and be included into the specifications by Addenda. Substitutions are for materials or manufacturers not listed in this specification. For each substitution proposed by the contractor, the contractor shall clearly indicate all differences from the specified item, change in Contract cost, benefit to the Owner, and a brief description why the substitution is being proposed. Refer to the General Conditions for additional information. The Owner shall ultimately accept/reject all substitution requests. Refer to the General Conditions of this specification for additional information.

1.13 FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA, or ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.14 REFERENCED STANDARDS, CODES AND SPECIFICATIONS:

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

AABC	-	Associated Air Balance Council
ABMA	-	American Boiler Manufacturers Association
ACCA	-	Air Conditioning Contractors of America
ACGIH	-	American Conference of Governmental Industrial Hygienist
ADC	-	Air Diffusion Council

AIHA	-	American Industrial Hygiene Association
AGA	-	American Gas Association
AMCA	-	Air Movement and Control Association
ANSI	-	American National Standards Institute
ARI	-	Air Conditioning and Refrigeration Institute
ASA	-	Acoustical Society of America
ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
AWWA	-	American Water Works Association
CABO	-	Council of American Building Officials
CAGI	-	Compressed Air and Gas Institute
CS	-	Commercial Standard
CSA	-	Canadian Standards Association
CTI	-	Cooling Tower Institute
HEI	-	Heat Exchanger Institute
HI	-	Hydraulic Institute
HYDI	-	Hydronics Institute
IAPMO	-	International Association of Plumbing and Mechanical Officials
IBC	-	International Building Code
IBR	-	Institute of Boiler and Radiator Manufacturers
ICBO	-	International Conference of Building Officials
IEEE	-	Institute of Electrical and Electronics Engineers
IFCI	-	International Fire Code Institute
IECC	-	International Energy Conservation Code
IMC	-	International Mechanical Code
IPC	-	International Plumbing Code
MSSP	-	Manufacturers Standards Society of the Valve and Fittings Industry
NEC	-	National Electrical Code
NEMA	-	National Electrical Manufacturers Association
NFPA	-	National Fire Protection Association
NSF Int.	-	National Sanitation Foundation
SMACNA	-	Sheet Metal and Air Conditioning Contractors National Association
TEMA	-	Tubular Exchanger Manufacturers Association
UL	-	Underwriters' Laboratories

1.15 SUBMITTALS, REVIEW AND ACCEPTANCE:

A. Equipment, materials, installation,workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Engineer to be in the best interest of the Owner.

B. Within 30 calendar days after award of contract, submit a complete Material and Equipment List for approval. List all proposed materials and equipment, indicating proposed manufacturer, type, class, model and other general identifying information.

C. After acceptance of Material and Equipment List, submit complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

D. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals. Each piece of equipment and its associated components (e.g., relays, fuses, disconnects, etc.) shall be clearly identified.

E. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

F. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For items other than first-named, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements if differences have not been clearly indicated in the submittal.

G. Submit actual operating conditions or characteristics, including NC Levels, for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable.

H. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.

I. Submit all LEED documentation indicating compliance with the contract requirements.

1.16 SHOP DRAWINGS:

A. Prepare and submit shop drawings for all specially fabricated items, modification to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on the Contract Drawings.

B. The Contractor, additionally, shall submit for approval any other shop drawings as required by the Architect. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Architect.

C. The Contractor shall coordinate layout with all lifts, structure and special equipment used within this facility. Coordinate all work with all drawings and specification requirements for this project.

1.17 SUPERVISION AND COORDINATION:

A. Provide complete supervision, direction, scheduling, and coordination of all work under the contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, and other work performed under Division 21.

C. Coordinate electrical work required under Division 21 with that under Division 26 and 28. Coordinate all work under Division 21 with work under all other Divisions.

1.18 CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 21. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, saw-cut or core drill only, and perform work in neat and workmanlike manner. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval.

1.19 PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish all necessary curbs, sleeves, flashings, fittings and caulking.

B. Where vents or other pipes penetrate roofs, flash pipe with All American, Inc., or approved equal, roof flashing assemblies, with 4-pound lead, 6-inch skirt, lead cap, and caulked counter-flashing sleeves.

C. Pitch pockets are prohibited.

D. Furnish and install roof drains, curbs, vent assemblies, and duct sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The National Roofing Contractors Association, SMACNA and as required by other Divisions to this specification. The Contractor shall be responsible for sleeve sizes and locations.

1.20 ACCESSIBILITY

A. All equipment shall be installed in such a way that all components requiring access (such as valves, flow switches, tamper switches, site glasses, disconnect switches, circuit breakers, starters, and accessories) are so located and installed that they may be serviced, reset, replaced, recalibrated, etc., by service technicians in accordance with the Manufacturer's recommendations. If any equipment or components are located in such a position that this Contractor cannot comply with the above, the Contractor shall notify the Engineer in writing before equipment is installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 21 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, galvanized steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Interior wet applied welding cements, adhesives, sealants, paints and coatings: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

2.4 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

A. Galvanized Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

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

1. Underdeck Clamp: Clamping ring with set screws.

C. Galvanized Steel Sheet Sleeves: Minimum thickness 0.0239"; round tube closed with welded longitudinal joint.

2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

2.7 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

M. Sleeves are required for core-drilled holes.

N. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

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

a. Exception: Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
a. Galvanized Steel Pipe Sleeves: For pipes through walls and floors except where noted through membrane waterproofing.
b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing. Seal space outside of sleeve fittings with grout.
c. Provide galvanized steel sheet sleeves for interior stud partitions.
d. Provide hot dipped galvanized steel wall sleeves with sleeve seal system for walls below grade and concrete slabs on grade. Select sleeve size to allow one-inch annular clear space between piping and sleeve for installing sleeve seal system. Select type, size and number of sealing elements required for piping material and size for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve 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 water-tight seal.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

S. Provide spool piece (ten (10) foot minimum) with flanges on each end for fire pump and piping specialties under base bid.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.

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

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1 for piping 2-1/2" and less. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Mechanical Joints: Use for piping 3" and larger; shall be rolled groove pipe.

3.3 PAINTING

A. Painting of fire-suppression systems, equipment, and components is specified in this Division Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc., shall be galvanized or stainless steel.

D. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

E. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

F. Protect all finishes and restore any finishes damaged to their original condition.

G. The preceding requirements apply to all work, whether exposed or concealed.

H. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

I. All exposed piping, equipment, etc. shall be painted. Colors shall be selected by the Architect and conform to ANSI Standards.

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.5 GROUTING

A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.6 SUPPORTS, HANGERS, AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For uninsulated copper piping/tubing provide copper hanger with wool or felt insert to prevent contact of dissimilar metals. All exterior hangers shall be constructed of galvanized steel or stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

3.7 PROVISIONS FOR ACCESS:

A. The Contractor shall provide access panels and doors for all concealed equipment, valves, strainers, controls, control devices, cleanouts, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured steel door assemblies consisting of hinged door, cam locks**,** and frame designed for the particular wall or ceiling construction. Properly locate each door. Door size shall be a minimum of 24" x 24" unless otherwise approved by the Architect/Engineer. Provide UL Approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, or approved equal.

1.	Acoustical or Cement Plaster:	Style B
2.	Hard Finish Plaster:	Style K or L
3.	Masonry or Dry Wall:	Style M

C. Where access is by means of lift-out ceiling tiles or panels, mark each panel using small color-coded or numbered tabs. Provide a chart or index for identification. Charts shall be similar to valve charts specified hereinafter. Provide chart in O & M Manual and in the Main Mechanical Equipment Room. Screw markers shall be mounted on the ceiling grid.

D. Access panels, doors, etc., described herein shall be furnished under the section of specifications providing the particular service to be turned over to the pertinent trade for installation. Coordinate installation with installing Contractor. Coordinate locations with the Architect prior to installation.

3.8 PROTECTION OF WORK:

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter.

C. Cover or protect all finishes.

D. Replace damaged materials, devices, finishes, and equipment.

3.9 OPERATION OF EQUIPMENT:

A. Clean all systems and equipment prior to initial operation for testing or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment.

C. Do not use fire protection systems for temporary services during construction.

D. Upon completion of work, clean and restore all equipment to new conditions; blowdown all strainers, etc.

3.10 RECORD DRAWINGS:

A. Upon completion of the fire suppression installations, the Contractor shall deliver to the Architect one complete set of prints and electronic PDF files with markups of the fire suppression contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. Provide a color scan of record drawings and provide in electronic format on a CD/DVD media or Flash Drive. They shall be suitable for use in preparation of Record Drawings.

3.11 GUARANTEE:

A. Contractor's attention is directed to guarantee obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of guarantee shall be included in the operations and maintenance manuals.

C. Contractor shall provide two (2) years full factory warranty on parts and labor for all equipment from the time of final acceptance of the fire suppression systems by the Owner. Warranty shall include 24-hour service. This service shall be rendered upon request when notified of any equipment malfunctions.

D. The guarantee shall not start until substantial completion of the project.

3.12 LUBRICATION:

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

C. Provide remote grease fittings with copper lube lines for air handling units, fans, cooling towers, and for bearings/motors where grease fittings are situated in locations inconvenient/inaccessible for lubrication.

D. Provide pressure relief fittings at all grease lubrication locations designed to automatically vent within the range of 1/4 to 1 psi, automatically reset below this range, or another pressure relief range if the preceding differs from the manufacturer's recommended pressure range.

3.13 RECORD AND INFORMATION BOOKLET:

A. The Contractor shall have prepared three (3) copies of the Record and Information Booklet and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three-ring loose-leaf binder similar to "National" No. 3881 with the following title lettered on the front: "Record and Information Booklet (insert name of the

project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pull-out.

C. All booklet information shall also be provided in electronic format, PDF files, stored on a CD/DVD, or Flash Drive. Each binder shall contain an envelope sleeve containing the electronic format media (CD's/DVD's or Flash Drives).

D. Provide the following data in the booklet:
   1. Catalog data on each piece of fire protection equipment furnished.
   2. Maintenance operation and lubrication instruction son each piece of equipment furnished.
   3. Complete catalog data on each piece of fire protection equipment furnished, including approved shop drawings, calculations, fire marshal approval, etc.
   4. Manufacturer's and Contractors' guarantees.
   5. Chart form indicating time and type of routine maintenance of the fire protection system and/or equipment. The chart shall also indicate tag number, model number of equipment, location and service. For replacement items such as filters, indicate type, size and quantity of the replaceable items.
   6. Provide sales and service representatives' names and phone numbers of all equipment and subcontractors.
   7. Catalog data of all equipment, valves, etc., which shall include wiring diagrams, parts list and assembly drawing.
   8. Provide valve chart including valve tag number, valve type, valve model number, valve manufacturer, style, service and location, etc., as specified hereinafter.
   9. Provide copies of all start-up reports.
   10. Provide certification that lead-free and asbestos-free products were provided.
   11. Provide operating curves indicating design and balanced conditions for pumps.
   12. Provide copies of all flushing reports.
   13. DVD's or Flash Drives of all demonstration and instruction periods.
   14. CD's/DVD's or Flash Drives of all coordination and/or fire protection drawings.

3.14 WIRING DIAGRAMS

A. Obtain and submit wiring diagrams for all equipment provided under this Contract.

B. Wiring diagrams shall be provided with Shop Drawings for similar to, but not limited to, all equipment.

C. The Contractor shall submit any additional wiring diagrams as requested by the Engineer.

D. Provide wiring diagrams and identify all termination points, connections and interface points for all major fire suppression equipment to the Electrical Contractor and the ATC Subcontractor for coordination.

3.15 FACTORY START-UP:

A. Provide one copy of all start-up reports to the Owner and include a copy in the O&M Manual.

3.16 FIRE SUPPRESSION INSTALLATIONS:

A. General: Sequence, coordinate, and integrate the various elements of fire suppression systems, materials, and equipment including, but not limited to, the following:

1. Coordinate fire suppression systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for fire suppression installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of fire suppression materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed, noted, or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of fire suppression systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished space.
10. Install fire suppression equipment to facilitate service, maintenance, and repair or replacement of equipment components in accordance with manufacturers' recommendations. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
11. Install access panels or doors where units are concealed behind finished surfaces.
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
13. Install above-ceiling equipment requiring servicing and/or maintenance within 48" of accessible ceilings/access panels.
14. Coordinate sprinkler piping and heads with all specialty equipment, lifts, bracing, etc. associated with special requirements for this facility. All sprinkler heads shall recessed type with flush cover plates.
15. All piping shall be concealed unless where the structure is exposed. Coordinate routing of exposed pipe with the Owner, Architect and Construction Manager prior to fabrication and installation. Extend sprinkler piping to high volume spaces (cafeteria, gym, etc.) from adjacent penthouses wherever possible.
16. All loading docks, canopies, etc. shall be protected by the sprinkler system. Use dry type sidewall heads wherever possible. Coordinate requirements with the authority having jurisdiction and location/layout with the Owner, Construction Manager, Architect and Engineer prior to fabrication and insallation.

- END OF SECTION 21 05 00 -

SECTION 21 05 23
GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION 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. Two-piece ball valves with indicators.
2. Bronze butterfly valves with indicators.
3. Iron butterfly valves with indicators.
4. Check valves.
5. Bronze OS&Y gate valves.
6. Iron OS&Y gate valves.
7. NRS gate valves.
8. Indicator posts.
9. Trim and drain valves.

1.3 DEFINITIONS

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

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

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

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

D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

1. Main Level: HAMV - Fire Main Equipment.

a. Level 1: HCBZ - Indicator Posts, Gate Valve.
b. Level 1: HLOT - Valves.

1) Level 3: HLUG - Ball Valves, System Control.
2) Level 3: HLXS - Butterfly Valves.
3) Level 3: HMER - Check Valves.
4) Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.

a. Level 1: VQGU - Valves, Trim and Drain.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:

a. Indicator posts.
b. Valves.

1) Gate valves.
2) Check valves.

a) Single check valves.

3) Miscellaneous valves.

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

D. ASME Compliance:

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

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

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

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

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

I. Valve Actuator Types:

1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 (DN 50) and smaller.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic company or as approved equal.

C. Description:

1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 (DN 25) through NPS 2 (DN 50): Threaded ends.
12. End Connections for Valves NPS 2-1/2 (DN 65): Grooved ends.

2.3 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:

   a. Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
   b. High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.

5. End Connections: Flanged or grooved.

B. Automatic (Ball Drip) Drain Valves:

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

   a. AFAC Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.

2. Standard: UL 1726.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4 (DN 20).
6. End Connections: Threaded.

2.4 SPRINKLER SPECIALTY PIPE FITTINGS

A. General Requirements for Dry-Pipe-System Fittings: UL listed for dry-pipe service.

B. Branch Outlet Fittings:

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

   a. Anvil International, Inc.
   b. National Fittings, Inc.
   c. Shurjoint Piping Products.
   d. Tyco Fire & Building Products LP.
   e. Victaulic Company.

2. Standard: UL 213.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

C. Flow Detection and Test Assemblies:

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

   a. AGF Manufacturing Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.

3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

D. Branch Line Testers:

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

   a. Elkhart Brass Mfg. Company, Inc.
   b. Fire-End & Croker Corporation.
   c. Potter Roemer.

2. Standard: UL 199.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

E. Sprinkler Inspector's Test Fittings:

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

   a. AGF Manufacturing Inc.
   b. Triple R Specialty.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.
   e. Viking Corporation.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

F. Adjustable Drop Nipples:

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. CECA, LLC.
   b. Corcoran Piping System Co.
   c. Merit Manufacturing; a division of Anvil International, Inc.

2. Standard: UL 1474.
3. Pressure Rating: 250 psig (1725 kPa) minimum.
4. Body Material: Steel pipe with EPDM O-ring seals.
5. Size: Same as connected piping.

6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Comply with requirements in the following Sections for specific valve installation requirements and applications:

1. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.

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

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

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

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

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

F. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

G. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

H. Coordinate with Division 22 and the authority having jurisdiction. Install backflow preventers instead of check valves in potable-water-supply sources.

- END OF SECTION 21 05 23 -

SECTION 21 05 53
IDENTIFICATION FOR FIRE-SUPPRESSION 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. Stencils.
5. Valve tags.
6. Warning tags.

1.3 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.

1.4 COORDINATION

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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths 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 based on the school district's PM Identification System.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

I. Label Content: Include caution and warning information, plus emergency notification instructions. Label per the school district standards.

2.3 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive for pipe sizes four-inches and less. For larger pipe sizes (six-inches and greater), markers shall be strapped around using nylon ties.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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 1-1/2 inches (38 mm) high.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME (ANSI) A13.1 for piping; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard or metal.
2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, alkyd enamel in colors according to ASME (ANSI) A13.1 unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) black-filled letters for piping system abbreviation and 1/2-inch (13-mm) black-filled numbers, 2-inch diameter.

1. Tag Material: Brass, 19 gauge minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass jack chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches (100 by 178 mm).
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Red background with white 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 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 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 with painted, color-coded bands or rectangles, complying with ASME (ANSI) A13.1, on each piping system.

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

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 15 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
8. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner to be easily legible from the floor.
9. For piping less than 3/4 inch, provide permanently legible tag as specified hereinbefore for valve identification.
10. For buried piping, provide 2-inch minimum width with plastic identification/detection tape with metallic core. Install 4 to 6-inches below-grade.

D. Pipe Label Color Schedule:

1. Sprinkler Piping:

a. Background Color: Red.
b. Letter Color: White.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units, etc. 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. Sprinkler Piping: 2 inches (50 mm), round.

2. Valve-Tag Color:

a. Sprinkler Piping: Red.

3. Letter Color:

a. Sprinkler Piping: White.

3.5 WARNING-TAG INSTALLATION

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

- END OF SECTION 21 05 53 -

SECTION 211119
FIRE-DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Flush-type fire-department connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.1 FLUSH-TYPE FIRE-DEPARTMENT CONNECTION

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide Potter Roemer 5000 series or comparable product by one of the following:

1. American Fire Hose & Cabinet.
2. Elkhart Brass Mfg. Company, Inc.
3. GMR International Equipment Corporation.
4. Guardian Fire Equipment, Inc.

C. Standard: UL 405.

D. Type: Flush, for wall mounting.

E. Pressure Rating: 175 psig (1200 kPa) minimum.

F. Body Material: Corrosion-resistant metal.

G. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Verify with the local fire department prior to ordering materials. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

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

I. Escutcheon Plate: Rectangular, brass, wall type.

J. Outlet: With pipe threads.

K. Body Style: Horizontal.

L. Number of Inlets: Two.

M. Outlet Location: Back.

N. Escutcheon Plate Marking: Similar to "AUTO SPKR."

O. Finish: Polished Brass.

P. Outlet Size: NPS 4 (DN 100).

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.

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

3.2 INSTALLATION

A. Install wall-type fire-department connections. Coordinate exact location with the authority having jurisdiction, the Owner, the Construction Manager and the Architect prior to installation.

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

- END OF SECTION 21 11 19 -

SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Sprinklers.
3. Alarm devices.
4. Pressure gages.

1.3 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig (1200 kPa) maximum.

1.4 SYSTEM DESCRIPTIONS

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

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional fire protection engineer, using performance requirements and design criteria indicated.

C. Sprinkler system design shall be stamped and signed by a registered fire protection engineer and approved by local fire marshal.

1. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.

2. Maximum Protection Area per Sprinkler: Per UL listing.

3. Total Combined Hose-Stream Demand Requirement: According to NFPA 13.

1.6 SUBMITTALS

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

B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, calculations, and attachments to other work. All detailed working drawings and associated hydraulic calculations shall be signed and sealed by a registered fire protection engineer prior to the submittal review process. The fire protection contractor shall prepare dimensioned and detailed working drawings and calculations and submit to the State, County and/or Local Fire Marshal for review and approval. Refer to Section 210500 for additional information.

C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations based on the current flow test performed by the Contractor.

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

E. Fire Flow Test: Perform a fire flow test and include results in the submittal.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

   a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a registered fire protection engineer.

B. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.8 COORDINATION

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

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. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

2. Coordinate mounting location with Owner.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes. All pipe and fittings shall meet the requirements of NFPA 13.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 10 and Schedule 40, Galvanized- and Black-Steel Pipe: ASTM A 53; ASTM A 53M, Type E; Grade B; with wall thickness not less than Schedule 10 or Schedule 40 as required. Pipe ends may be factory or field formed to match joining method. Cut groove ends are prohibited.

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

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

D. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

E. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

F. Roll-Grooved-Joint, Steel-Pipe Appurtenances:

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

a. Anvil International, Inc.
b. Corcoran Piping System Co.
c. Tyco Fire & Building Products LP.
d. Victaulic Company.

2. Pressure Rating: 175 psig (1200 kPa) minimum.
3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

G. Steel pipe nipples: Galvanized or black steel, ASTM A 733 made of ASTM A53/A53M standard weight, seamless steel pipe with threaded ends.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Reliable Automatic Sprinkler Co., Inc.
2. Tyco Fire & Building Products LP.
3. Viking Corporation.
4. Victaulic Company.
5. Globe Fire Sprinkler Corporation.

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
3. Provide extended escutcheons in rooms with surface-mounted lighting fixtures.
4. Provide freeze-proof heads for canopy’s, loading docks, freezers, etc., where freezing conditions exist.
5. Additional heads shall be furnished as required by NFPA 13. The heads shall be in a cabinet designed to hold the heads and include one sprinkler head wrench for each type of sprinkler. Cabinet shall be mounted where indicated in the field. Coordinate location with Owner.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Non-residential applications: UL 199.
3. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Sprinkler Finishes:

1. White/Painted.
2. Concealed sprinkler round flush cover plates (white) for all ceiling sprinkler heads.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Flat concealed pendent Viking VK 462 with flush white cover plate assembly.
2. Sidewall Mounting: Concealed horizontal sprinkler, Viking VK 481 (painted white) where exposed to a finished space. Horizontal exposed sidewall sprinkler, Viking VK 305 (brass or white) where exposed to an unfinished space.
3. Conventional Upright: Viking VK 300, brass where exposed in unfinished space (mechanical rooms) and white where exposed to occupied spaces.
4. Extended Coverage:
   a. Concealed Pendent: Viking VK 632 (light hazard)
      Viking VK 538 (ordinary hazard)
   b. Horizontal Side Wall: Viking VK 605 (light hazard)
   c. Upright: Viking VK 532 (light/ordinary hazard)
   d. Pendent: Viking VK 600 (light hazard), VK 534 (ordinary hazard)

F. Sprinkler Guards:

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

   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Viking Corporation.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.5 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections. Approved water flow switches shall be installed to activate the fire alarm system. All valves controlling water supply for sprinklers shall be electrically supervised in accordance with requirements of NFPA 13 and NFPA 72. Coordinate requirements with Division 28.

B. Water-Motor-Operated Alarm:

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

   a. Globe Fire Sprinkler Corporation.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   d. Viking Corporation.

2. Standard: UL 753.
3. Type: Mechanically operated, with Pelton wheel.
4. Alarm Gong: Cast aluminum with red-enamel factory finish.
5. Size: 10-inch (250-mm) diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4 (DN 20).
8. Outlet: NPS 1 (DN 25) drain connection.

C. Water-Flow Indicators:

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

    a. ADT Security Services, Inc.
    b. McDonnell & Miller; ITT Industries.
    c. Potter Electric Signal Company.
    d. System Sensor; a Honeywell company.
    e. Viking Corporation.
    f. Watts Industries (Canada) Inc.

2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig (1725 kPa).
7. Design Installation: Horizontal or vertical.

D. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Barksdale, Inc.
    b. Detroit Switch, Inc.
    c. Potter Electric Signal Company.
    d. System Sensor; a Honeywell company.
    e. Tyco Fire & Building Products LP.
    f. United Electric Controls Co.
    g. Viking Corporation.

2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

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

    a. Fire-Lite Alarms, Inc.; a Honeywell company.
    b. Kennedy Valve; a division of McWane, Inc.
    c. Potter Electric Signal Company.
    d. System Sensor; a Honeywell company.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.6 PRESSURE GAUGES

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

   1. AMETEK; U.S. Gauge Division.
   2. Ashcroft, Inc.
   3. Brecco Corporation.
   4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

D. Pressure Gauge Range: 0 to 250 psig (0 to 1725 kPa) minimum.

E. Case: Dry, sealed, type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.

F. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

G. Match pressure connection size in first subparagraph below with gage attachment size.

H. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

I. Movement: Mechanical, with link to pressure element and connection to pointer.

J. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).

K. Pointer: Dark-colored metal.

L. Window: Glass.

M. Ring: Stainless steel.

N. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

O. All gauges at pumps shall be liquid filled type.

P. Water System Piping Gauge: Include "WATER" label on dial face.

2.7 SPECIALTY VALVES

A. General Requirements:

   1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   2. Pressure Rating:

      a. Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.

   3. Body Material: Cast or ductile iron.
   4. Size: Same as connected piping.
   5. End Connections: Flanged or grooved.

B. Alarm Valves:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Globe Fire Sprinkler Corporation.
      b. Reliable Automatic Sprinkler Co., Inc.
      c. Tyco Fire & Building Products LP.
      d. Victaulic Company.
      e. Viking Corporation.

   2. Standard: UL 193.
   3. Design: For horizontal or vertical installation.

4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
5. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

C. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.

2. Standard: UL 1726.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4 (DN 20).
6. End Connections: Threaded.

2.8 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

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

   a. Anvil International, Inc.
   b. National Fittings, Inc.
   c. Shurjoint Piping Products.
   d. Tyco Fire & Building Products LP.
   e. Victaulic Company.

2. Standard: UL 213.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

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

   a. AGF Manufacturing Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.

4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. Branch Line Testers:

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

   a. Elkhart Brass Mfg. Company, Inc.
   b. Fire-End & Croker Corporation.
   c. Potter Roemer.

2. Standard: UL 199.
3. Pressure Rating: 175 psig (1200 kPa).
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

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

   a. AGF Manufacturing Inc.
   b. Triple R Specialty.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.
   e. Viking Corporation.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prepare calculations based on a gravity water tank with fire pump in accordance with NFPA requirements. Use results for system design calculations required in "Quality Assurance" Article.

3.2 SERVICE-ENTRANCE PIPING

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

B. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Division 22 Section "Domestic Water Piping."

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

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.4 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

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

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

D. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

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

G. Install sprinkler piping with drains for complete system drainage. Means of drainage shall be provided with adequate protection from freezing. Drain valve may be combined with sprinkler alarm test valve and site glass. Valve shall be UL listed with positive positioning handle for OFF, TEST or DRAIN, integral site glass, orifice size equal to smallest sprinkler orifice and full one-inch drain.

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

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

J. Install alarm devices in piping systems.

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

L. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

M. Fill sprinkler system piping with water.

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 21 Section "Sleeves and Sleeve Seals for Fire-Suppression Piping."

O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 21 Section "Sleeves and Sleeve Seals for Fire-Suppression Piping."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 21 Section "Escutcheons for Fire-Suppression Piping."

3.5 JOINT CONSTRUCTION

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

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

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

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

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

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

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

3.6 VALVE AND SPECIALTIES INSTALLATION

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

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

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

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

3.7 SPRINKLER INSTALLATION

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

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

C. Provide head guards on heads in mechanical and electrical rooms, janitor closets, storage rooms, gym, mechanical penthouses and all rooms where heads are exposed.

3.8 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, flush fire-department connections.

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

3.9 IDENTIFICATION

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

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run excess-pressure pumps.
6. Coordinate with fire-alarm tests. Operate as required.
7. Verify that equipment hose threads are same as local fire-department equipment.

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

D. Prepare and submit to Architect, test and inspection reports.

3.11 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.12 PIPING SCHEDULE

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

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

C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2” and smaller shall be Schedule 40.

1. Schedule 40 black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 3” and larger shall be one of the following:

1. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
2. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.13 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers with white coverplate.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces subject to freezing: Dry Sprinklers.

3.14 LAYOUT

A. Coordinate layout and installation of fire protection system with all other buildings structural, mechanical and electrical work. Locate sprinkler heads in the center of ceiling tiles and symmetrically with respect to ceiling tiles, lighting fixtures, registers, grilles, diffusers, etc. Provide piping offsets as required to maintain symmetry. Sprinkler pipe velocity shall not exceed eighteen (18) feet per second (fps). The system design shall limit maximum demand flow rates at 25% greater than the design requirement established by NFPA. Note that a preliminary sprinkler layout is to be submitted for review. Contractor is cautioned that sprinkler mains must be located to prevent conflicts with other work and in any case, Sprinkler Contractor shall be responsible for coordination of his work with work of other trades. Air terminal devices, units, and equipment shall be indicated on the coordinated layout/shop drawing. For exposed areas, conceal piping and utilize sidewall heads wherever possible, including in conjunction with pendant heads where required. For exposed piping, get approval from the Architect, Construction Manager, Owner and Engineer of proposed location and routing prior to fabrication and installation of systems.

3.15 WET PIPE SPRINKLER SYSTEM:

A. System components shall include flow control valve, electrical connection to central fire alarm system, Siamese fire department connection, check valves, main piping, branch piping, inspector's test, drains, sprinkler heads, and all other incidental appurtenances as required. Provide dry type sprinkler system wherever the sprinkler system is subject to freezing.

B. At the Contractors option, and upon approval of the authority of having jurisdiction, the use of flexhead sprinkler hose and bracket (ul & fm approved) sprinkler connection shall be permitted.

3.16 TESTS:

A. The Sprinkler systems installation shall be hydrostatically tested, inspected, and approved, in accordance with NFPA Standard No. 13. Test certificate shall be forwarded to the Office of the State Fire Marshal, and the Local Fire Department, as proof of compliance.

B. Tests shall be performed in accordance with the requirements of the Office of the State Fire Marshal or Local Fire Department, as required, and shall prove the systems to be adequate and satisfactory in every respect. All tests shall be performed in the presence of the State or Local Fire Marshal or his representative.

C. Any deficiencies revealed by these tests shall be corrected and the systems shall be retested until acceptable results are obtained.

3.17 AS-BUILT DRAWINGS:

A. Provide separate as-built drawings of all fire protection systems meeting requirements of General Mechanical Requirements hereinbefore specified. Provide hard copies and electronic copies to the Owner.

3.18 GUARANTEE:

A. The Contractor’s attention is directed to the guarantee obligations contained in section 210500.

- END OF SECTION 211313 -

SECTION 21 31 13
ELECTRIC-DRIVE, CENTRIFUGAL FIRE 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. Vertical in-line fire pumps.
2. Fire-pump accessories and specialties.
3. Flowmeter systems.

B. Fire pump and all associated accessories, materials and equipment are under add alternate #9.

1.3 PERFORMANCE REQUIREMENTS

A. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. 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.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, 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 fire pump, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps to include in 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. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

A. Provide two (2) year warranty.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.2 VERTICALLY MOUNTED IN-LINE TYPE FIRE PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. A-C Fire Pump Systems; a business of ITT Industries.
2. Patterson Pump Company; a subsidiary of the Gorman-Rupp Company.

3. Peerless Pump, Inc.
4. Pentair Pump Group; Aurora Pump.
5. Pentair Pump Group; Fairbanks Morse.
6. S.A. Armstrong Limited.

B. Pump:

1. Standard: UL 448, for split-case pumps for fire service.
2. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
3. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: Steel shaft with stainless steel sleeve.

a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

6. Mounting: Pump and driver shaft is vertical, with motor above pump and pump on base.

C. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

D. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.

E. Capacities and Characteristics: Refer to Drawings.

2.3 FLOWMETER SYSTEMS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Emerson Process Management; Rosemount Division.
2. Fire Research Corp.
3. Gerand Engineering Co.
4. Hydro Flow Products, Inc.
5. Hyspan Precision Products, Inc.
6. Meriam Process Technologies.
7. Preso Meters; Division of Racine Federated Inc.
8. Victaulic Company.

B. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.

C. Pressure Rating: 175 psig (1200 kPa) minimum.

D. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.

E. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.

1. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper tubing with copper or brass fittings and valves.

F. Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

2.4 GROUT

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

B. Characteristics: Nonshrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps 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 equipment bases and anchorage provisions, with Installer present, for compliance with requirements and for conditions affecting performance of fire pumps.

B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.

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

3.2 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete".

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.

D. Support piping and pumps separately so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

F. Install pressure gauges on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Section 211313 "Wet-Pipe Sprinkler Systems."

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

J. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.3 CONNECTIONS

A. Comply with requirements for piping and valves specified in Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to drainage piping or point of discharge.

D. Connect flowmeter-system meters, sensors, and valves to tubing.

E. Connect fire pumps to their controllers.

3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.5 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 213900 "Controllers for Fire-Pump Drivers."

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 components, assemblies, and equipment including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

G. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

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 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

- END OF SECTION 213113 -

SECTION 21 34 00
PRESSURE-MAINTENANCE 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. Regenerative-turbine, pressure-maintenance pumps.

B. Related Section:

   1. Section 213900 "Controllers for Fire-Pump Drivers" for pressure-maintenance-pump controllers.

1.3 PERFORMANCE REQUIREMENTS

A. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For pumps, accessories, and specialties. 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.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in 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.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

A. Provide two (2) year warranty from substantial completion.

PART 2 - PRODUCTS

2.1 REGENERATIVE-TURBINE, PRESSURE-MAINTENANCE PUMPS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide PACO Pumps; Grundfos Pumps Corporation U.S.A or comparable product by one of the following:

1. Crane Pumps and Systems; a Crane Co. company.
2. MTH Pumps/MTH Tool Company, Inc.
3. A-C Fire Pump Systems; a business of ITT Industries.
4. Aurora Pump

C. Description: Factory-assembled and -tested, close-coupled, single-stage, regenerative-turbine centrifugal pump as defined in HI 1.1-1.2 and HI 1.3; with pump and motor mounted horizontally.

D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded inlet and outlet.
2. Impeller: Bronze, balanced, and keyed to shaft.
3. Pump Shaft: Stainless steel with deflector.
4. Shaft Sleeve: Bronze.
5. Seal: Mechanical type with spring-loaded rotating head.

E. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."

1. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.

F. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

G. Capacities and Characteristics:
1. Refer to Drawings.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression 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.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.

B. Base-Mounted Pump Mounting: Install pumps on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Attach pumps to equipment base using anchor bolts.

C. Install regenerative-turbine, pressure-maintenance pumps according to HI 1.4.

D. Coordinate all requirements with the Electrical Contractor at the shop drawing phase through the installation phase.

3.2 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. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.3 ADJUSTING

A. Lubricate pumps as recommended by manufacturer.

B. Set field-adjustable pressure-switch ranges as indicated.

- END OF SECTION 21 34 00 -

SECTION 21 39 00
CONTROLLERS FOR FIRE-PUMP DRIVERS

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. Full-service, reduced-voltage controllers rated 600 V and less.
2. Limited-service controllers rated 600 V and less.
3. Controllers for pressure-maintenance pumps.
4. Remote alarm panels.
5. Low-suction-shutdown panels.

1.3 DEFINITIONS

A. ATS: Automatic transfer switch(es).

B. ECM: Electronic control module.

C. MCCB: Molded-case circuit breaker.

D. N.O.: Normally open.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For each type of product indicated. Include dimensioned plans, elevations, sections, details, and attachments to other work, including required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Enclosure types and details for types other than NEMA 250, Type 2.
c. Factory-installed devices.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of integrated unit.
f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
g. Specified modifications.

2. Detail equipment assemblies and indicate dimensions, weights, loads, method of field assembly, components, and location and size of each field connection.
3. Schematic and Connection Diagrams: For power, signal, alarm, and control wiring and for pressure-sensing tubing.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Product Certificates: For each type of product indicated, from manufacturer.

C. Manufacturer's factory test reports of fully assembled and tested equipment.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product indicated to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 and 210500, include the following:

1. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
2. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor-based logic controls.

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. Indicating Lights: Two of each type and color of lens installed; two of each type and size of lamp installed.
2. Auxiliary Contacts: One for each size and type of magnetic contactor installed.
3. Power Contacts: Three for each size and type of magnetic contactor installed.
4. Contactor Coils: One for each size and type of magnetic controller installed.
5. Relay Boards: One for each size and type of relay board installed.
6. Operator Interface: One microprocessor board(s), complete with display and membrane keypad.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of an NRTL.

B. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.

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

D. Comply with standards of authorities having jurisdiction pertaining to materials and installation.

E. Comply with NFPA 20 and NFPA 70.

F. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 COORDINATION

A. Coordinate layout and installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.11 WARRANTY

A. Provide two (2) year warranty.

PART 2 - PRODUCTS

2.1 FULL-SERVICE CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ASCO Power Technologies, LP; Firetrol Products.
   2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Hubbell Incorporated; Hubbell Industrial Controls.
   4. Joslyn Clark Corporation.

B. General Requirements for Full-Service Controllers:

   1. Comply with NFPA 20 and UL 218.
   2. Listed by an NRTL for electric-motor driver for fire-pump service.
   3. Combined automatic and nonautomatic operation.
   4. Factory assembled, wired, and tested; continuous-duty rated.
   5. Service Equipment Label: NRTL labeled for use as service equipment.

C. Method of Starting:

   1. Pressure -switch actuated.

a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
b. System pressure recorder, electric ac driven, with spring backup.
c. Programmable minimum-run-time relay to prevent short cycling.
d. Programmable timer for weekly tests.

2. Magnetic Controller: Autotransformer type.
3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.

D. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting.

E. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.

F. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.

G. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

a. Microprocessor-based logic controller, with multiline digital readout.
b. Membrane keypad.
c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

a. Controller power on.
b. Motor running condition.
c. Loss-of-line power.
d. Line-power phase reversal.
e. Line-power single-phase condition.
f. Transfer Switch Position.

4. Audible alarm, with silence push button.
5. Nonautomatic START and STOP push buttons or switches.

H. Optional Features To be Provided:

1. Extra Output Contacts:

a. One N.O. contact(s) for motor running condition.
b. One set(s) of contacts for loss-of-line power.
c. One each, Form C contacts for high and low reservoir level.

2. Local alarm bell.
3. Door-mounted thermal or impact printer for alarm and status logs.
4. Operator Interface Communications Ports: USB, Ethernet, and RS485.
5. Interlock with building BACNET automatic temperature control system, coordinate with Mechanical Contractor.

6. Pilot Lamp: Indicate circuit breaker closed and power available.

I. ATS:

1. Complies with NFPA 20, UL 218, and UL 1008.
2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
4. Allows manual transfer from one source to the other.
5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
7. Local and Remote Alarm and Status Indications:

    a. Normal source available.
    b. Alternate source available.
    c. In normal position.
    d. In alternate position.
    e. Isolating means open.
    f. Phase Reversal.
    g. Pump Running.

8. Audible alarm, with silence push button.
9. Nonautomatic (manual, nonelectric) means of transfer.
10. Engine test push button.
11. Start generator output contacts.
12. Timer for weekly generator tests.

2.2 CONTROLLERS FOR PRESSURE-MAINTENANCE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ASCO Power Technologies, LP; Firetrol Products.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. Hubbell Incorporated; Hubbell Industrial Controls.
4. Joslyn Clark Corporation.

B. General Requirements for Pressure-Maintenance-Pump Controllers:

1. Type: UL 508 factory assembled, -wired, and tested, across-the-line; for combined automatic and manual operation.
2. Enclosure: UL 508 and NEMA 250, Type 2 for wall-mounting.
3. Factory assembled, wired, and tested.
4. Finish: Manufacturer's standard color paint.

C. Rate controller for scheduled horsepower and include the following:

1. Fusible disconnect switch.
2. Pressure switch.

3. Hand-off-auto selector switch.
4. Pilot light.
5. Running period timer.
6. Full voltage starter.
7. Independent “high” and “low” adjustment points or pressure switch.

2.3 ENCLOSURES

A. Fire-Pump Controllers, ATS, Remote Alarm Panels, and Low-Suction-Shutdown Panels: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.
   1. Other Wet or Damp, Indoor Locations: Type 4 (IEC IP56).

B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".

C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.

D. Optional Features:

   1. Floor stands, 12 inches (305 mm) high, for floor-mounted controllers.

2.4 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.

   1. Verification of Performance: Rate controllers according to operation of functions and features specified.

B. Fire-pump controllers 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 and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.

B. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.

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

3.2 CONTROLLER INSTALLATION

A. Install controllers within sight of their respective drivers.

B. Connect controllers to their dedicated pressure-sensing lines.

C. Floor-Mounting Controllers: Install controllers on 4-inch (100-mm) nominal-thickness concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Comply with NEMA ICS 15.

F. Coordinate all requirements with the Electrical Contractor at the shop drawing phase through the installation phase.

3.3 STANDALONE ATS INSTALLATION

A. Floor-Mounting ATS: Install ATS on 4-inch (100-mm) nominal-thickness concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.4 POWER WIRING INSTALLATION

A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables." All control cabling between the Fire Pump Control Panel and Emergency Generator shall have a minimum 2-Hour Fire Rating. Product must be MI cable, 2-inch concrete encasement or other approved UL listed assemblies.

3.5 CONTROL AND ALARM WIRING INSTALLATION

A. Install wiring between controllers and remote devices and facility's central monitoring system. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."

B. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 283111 "Digital, Addressable Fire-Alarm System."

C. Bundle, train, and support wiring in enclosures.

D. Connect remote manual and automatic activation devices where applicable.

3.6 IDENTIFICATION

A. Comply with requirements in NFPA 20 for marking fire-pump controllers.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a Manufacturers qualified testing agency to perform tests and inspections. All tests shall be witnessed by the Commissioning Agent, Construction Manager and Owner.

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. Inspect and Test Each Component:

a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
c. Test continuity of each circuit.

2. Verify and Test Each Electric-Driver Controller:

a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Construction Manager before starting the motor(s).
b. Test each motor for proper phase rotation.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Field Acceptance Tests:

1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Construction Manager and authorities having jurisdiction.
2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
3. Engage manufacturer's factory-authorized service representative to be present during the testing.
4. Perform field acceptance tests as outlined in NFPA 20.

F. Controllers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.8 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.

3.9 ADJUSTING

A. Adjust controllers to function smoothly and as recommended by manufacturer.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.

C. 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.

D. Set field-adjustable pressure switches.

3.10 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controllers, and to use and reprogram microprocessor-based controls within this equipment.

- END OF SECTION 21 39 00 -

SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

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. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with "Submittals" specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 22 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

C. LEED Submittals: Comply with Section 08113

1. EQ Credit 2: Low-Emitting materials

a. For interior wet applied welding cements, adhesives, sealants, paints, coatings: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method V1.1-2010 and VOC content in g/l. Include volume of material applied per product.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations. Coordinate the work under Division 22 with work of all other construction trades. Conform to the requirements of all rules, regulations, and Codes of local, state, and Federal Authorities Having Jurisdiction.

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

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces.

1.8 PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the General Requirements of the specification.

1.9 EXAMINATION OF SITE:

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for Contractor's failure to do so.

1.10 CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 22 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence if requested.
   1. A list of not less than five comparable projects that the Contractor completed.
   2. Letter of reference from not less than three registered professional engineers, Contractors or building owners.
   3. Local and/or State License, where required.
   4. Membership trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.11 MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. This Contractor shall be responsible for connecting all utilities as shown on the drawings, to equipment identified as "under another Division".

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal only of other manufacturers who are indicated in this specification, subject to approval by the Engineer and the Owner. Alternate manufacturers or items other than the first-named shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Alternate manufacturers/items are items other than first named which shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Manufacturers not named are not acceptable and shall not be submitted.

D. Substitution will not be permitted for specified items of material or equipment where only one manufacturer is identified.

E. The Contractor shall only submit those manufacturers indicated in the specification. Proposed alternate manufacturers must be approved by the Owner and be included into the specifications by Addenda. Substitutions are for materials or manufacturers not listed in this specification. For each substitution proposed by the Contractor, the Contractor shall clearly indicate all differences from the specified item, change in Contract cost, benefit to the Owner and a brief description why the substitution is being proposed. Refer to the General Conditions for additional information. The Owner shall ultimately accept/reject all substitution requests. Refer to the General Conditions of this specification for additional information.

F. All cost associated with differences for alternate manufacturers shall be at no additional cost to the Owner. Differences that affect other trades for alternate manufacturers shall be coordinated during the bid phase and included in the bids (i.e. no additional cost to the Owner.)

1.12 FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA OR ASTM Standards for Fire Safety with Smoke and Fire Hazard Rating not exceeding flame spread of 25 and smoke developed of 50.

1.13 REFERENCED STANDARDS, CODES AND SPECIFICATIONS:

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

AABC - Associated Air Balance Council
ABMA - American Boiler Manufacturers Association
ACCA - Air Conditioning Contractors of America
ACGIH - American Conference of Governmental Industrial Hygienist
ADC - Air Diffusion Council
AIHA - American Industrial Hygiene Association
AGA - American Gas Association
AMCA - Air Movement and Control Association
ANSI - American National Standards Institute
ARI - Air Conditioning and Refrigeration Institute
ASA - Acoustical Society of America
ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME - American Society of Mechanical Engineers
ASTM - American Society for Testing and Materials
AWWA - American Water Works Association
CABO - Council of American Building Officials
CAGI - Compressed Air and Gas Institute
CS - Commercial Standard
CSA - Canadian Standards Association
CTI - Cooling Tower Institute
HEI - Heat Exchanger Institute
HI - Hydraulic Institute
HYDI - Hydronics Institute
IAPMO - International Association of Plumbing and Mechanical Officials
IBC - International Building Code
IBR - Institute of Boiler and Radiator Manufacturers
ICBO - International Conference of Building Officials
IEEE - Institute of Electrical and Electronics Engineers
IFCI - International Fire Code Institute
IMC - International Mechanical Code
IPC - International Plumbing Code
MSSP - Manufacturers Standards Society of the Valve and Fittings Industry
NEC - National Electrical Code
NEMA - National Electrical Manufacturers Association
NFPA - National Fire Protection Association
NSF Int. - National Sanitation Foundation
SMACNA - Sheet Metal and Air Conditioning Contractors National Association
TEMA - Tubular Exchanger Manufacturers Association
UL - Underwriters' Laboratories

B. All mechanical equipment and materials shall comply with the Codes and Standards listed in the latest ASHRAE Handbook.

1.14 SUBMITTALS, REVIEW AND ACCEPTANCE:

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Engineer to be in best interest of Owner.

B. With 30 calendar days after award of contract, submit a complete Material and Equipment List for approval. List all proposed materials and equipment, indicating proposed manufacturer, type, class, model and other general identifying information.

C. After acceptance of Material and Equipment List, submit complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

D. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals. Each piece of equipment and its associated components (e.g., relays, fuses, disconnects, etc.) shall be clearly identified.

E. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

F. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For items other than first-named, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements if differences have not been clearly indicated in the submittal.

G. Submit actual operating conditions or characteristics, including NC Levels, for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable.

H. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.

I. The Contractor is responsible for notifying the Owner of any changes, substitutions and/or alternative materials/manufacturers that are proposed as equal after the project has bid or submittal has been received.

J. The Contractor is responsible for all cost and coordination for other trades if alternative manufacturers are submitted.

1.15 SHOP DRAWINGS:

A. Prepare and submit shop drawings for all specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings as listed below, in addition to provisions of Paragraph A above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number.
Items and Systems Not Limited to:

Access Doors.
Backflow Preventer.
Capacitors.
Fire Stopping - Methods and Materials.
Floor & Roof Drains.
Flowmeters and Primary Elements. (Flow Fittings)
Hot Water Heater
Hose Bibbs & Wall Hydrants.
Identification System.
Mixing Valve, Temperature Limiting Valves.
Pipe Guides and Anchors.
Pipes and Fittings.
Plumbing Fixtures & Trim.
Pressure Regulating Valve.
Pressure Reducing Valve.
Pressure Relief Valve.
Sleeves and Sealants.
Strainers.
Thermal Insulation Materials.
Thermometers and Gauges.
Trap Seals.
Valves - Globe, Angle, Check, Plug, Butterfly, Ball.
Vibration Isolation.

C. The Contractor, additionally, shall submit for approval any other shop drawings as required by the Architect. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Architect.

D. Submit all items and material for LEED compliance.

1.16 SUPERVISION AND COORDINATION:

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, and other work performed under Division 22.

C. Coordinate electrical work required under Division 22 with that under Division 26. Coordinate all work under Division 22 with work under all other Divisions.

1.17 CUTTING AND PATCHING:

A. Accomplish all cutting and patching necessary for the installation of work under Division 22. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, saw-cut or core drill only, and perform work in neat and workmanlike manner. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval.

1.18 PENETRATION OF WATERPROOF CONSTRUCTION:

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where plumbing vents or other pipes penetrate roofs, flash pipe with All American, Inc., or approved equal, roof flashing assemblies, with 4-pound lead, 6-inch skirt, lead cap, and caulked counterflashing sleeve. Refer to architectural drawings for additional information.

C. Furnish pipe curbs and portals where required. Pitch pockets are prohibited.

D. Furnish and install roof drains, curbs, vent assemblies, and pipe sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions, The National Roofing Contractors Association, SMACNA and as required by other divisions of this specification. The Contractor shall be responsible for sleeve sizes and locations.

1.19 VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors, and/or foundations required to prevent transmission of vibration from equipment or piping to building structure.

1.20 ACCESSIBILITY

A. All equipment shall be installed in such a way that all components requiring access are so located and installed that they may be serviced, reset, replaced, recalibrated, etc., by service technicians in accordance with the Manufacturer’s recommendations. If any equipment or components are located in such a position that this Contractor cannot comply with the above, the Contractor shall notify the Engineer in writing before equipment is installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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 manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

    a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, galvanized steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

H. Interior wet applied welding cements, adhesives, sealants, paints and coatings: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
1. Manufacturers:

    a. Cascade Waterworks Mfg. Co.
    b. Dresser Industries, Inc.; DMD Div.

c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
d. JCM Industries.
e. Smith-Blair, Inc.
f. Viking Johnson.

2. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:

a. Eslon Thermoplastics.

b. Charlotte Pipe.

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:

a. Thompson Plastics, Inc.
b. Charlotte Pipe**.**

D. Plastic-to-Metal Transition Unions: MSS SP-107, PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Manufacturers:

a. NIBCO INC.
b. NIBCO, Inc.; Chemtrol Div.
c. Charlotte Pipe**.**

E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Fernco, Inc.
c. Mission Rubber Company.
d. Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

1. Manufacturers:
   a. Epco Sales, Inc.
   b. Watts Industries, Inc.; Water Products Div.
   c. Flowset.

D. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Manufacturers:

   a. Perfection Corp.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Co., Inc.
   d. Victaulic Co. of America.

E. Dielectric Unions and Couplings are prohibited.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless Steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

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

1. Underdeck Clamp: Clamping ring with set screws.

C. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

D. All underground wall sleeves must be galvanized schedule 40 piping.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

C. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. 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 with spring clips.
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.

M. Permanent sleeves are not required for holes formed by removable PE sleeves.

N. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

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

a. Exception: Extend sleeves installed in floors 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are two pipe sizes larger than pipe or pipe insulation.
a. Galvanized Steel Pipe Sleeves: For pipes through walls and floors except where noted through membrane waterproofing.
b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing. Seal space outside of sleeve fittings with grout.
c. Provide galvanized steel sheet sleeves for interior stud partitions.
d. Provide galvanized steel wall sleeves with sleeve seal system for walls below grade and concrete slabs on grade. Select sleeve size to allow one-inch annular clear space between piping and sleeve for installing sleeve seal system. Select type, size and number of sealing elements required for piping material and size for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve 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 water-tight seal.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size two pipe sizes larger than pipe and sleeve for installing mechanical sleeve seals.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using 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.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

U. Provide 4” or larger odor hog activated carbon, odor control vapor phase vent pipe filter for all plumbing vent terminations.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

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

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.
5. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting" unless noted otherwise.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces

with rust-inhibiting paint. All exterior components including supports, hangers, vibration isolators, etc., shall be galvanized or stainless steel. All fasteners including nuts, bolts, washers, rods, etc., shall be stainless steel.

D. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

E. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

F. Protect all finishes and restore any finishes damaged as a result of work under Division 22 to their original condition.

G. The preceding requirements apply to all work, whether exposed or concealed.

H. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

I. All exposed piping, equipment, cast iron boots, etc. shall be painted. Colors shall be selected by the Architect and conform to ANSI Standards.

J. All gas piping (exposed and concealed) shall be painted yellow by the Plumbing contractor.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 5000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.9 SUPPORTS AND HANGERS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For uninsulated copper piping/tubing provide copper clad hanger. All exterior hangers shall be constructed of galvanized steel or stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

3.10 PROVISIONS FOR ACCESS:

A. The Contractor shall provide access panels and doors for all concealed equipment, valves, strainers, cleanouts, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured steel door assemblies consisting of hinged door, cam locks**,** and frame designed for the particular wall or ceiling construction. Properly locate each door. All proposed access door locations shall be approved by the Architect prior to installation. Door size shall be a minimum of 24" x 24" unless otherwise approved by the Architect/Engineer. Provide UL Approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, or approved equal.

1. Acoustical or Cement Plaster: Style B
2. Hard Finish Plaster: Style K or L
3. Masonry or Dry Wall: Style M

C. Where access is by means of lift-out ceiling tiles or panels, mark each panel using small color-coded or numbered tabs. Provide a chart or index for identification. Charts shall be similar to

valve charts specified hereinafter. Provide chart in O & M Manual and in the Mechanical Equipment Room. Screw markers shall be mounted on the ceiling grid using the owner's standard for marking and ID.

D. Access panels, doors, etc., described herein shall be furnished under the section of specifications providing the particular service to be turned over to the pertinent trade for installation. Coordinate installation with installing Contractor. Coordinate locations with the Architect prior to installation.

3.11 PROTECTION OF WORK:

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

3.12 OPERATION OF EQUIPMENT:

A. Clean all systems and equipment prior to initial operation for testing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment.

C. Do not use plumbing systems for temporary services during construction unless authorized in writing by the Owner or Architect. Where such authorization is granted, temporary use of equipment shall in no way limit or otherwise affect warranties or guaranty period of the work. All equipment safeties shall be functional and equipment operated within the recommended and designed parameters.

D. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters, blowdown all strainers, etc.

3.13 IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate valve location, service, type (i.e., butterfly, globe, ball, etc.) make, model number and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under glass and hung in the Mechanical Room where directed. Contractor shall deliver the AutoCAD or Revit developed color print and DVD/CD or Flash Drive from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged.

C. All items of equipment shall be furnished with white letters and numbers on laminated identification plates using the owner's coding system to match the owner's PM system requirements. Lettering shall be a minimum of 1/4" high. Identification plates shall be securely affixed to each piece of equipment, starters, panels, etc., by screws or adhesive (Tuff-bond #TB2 or as approved equal). Pressure sensitive tape backing is prohibited for all concealed equipment and devices located above drop tile ceilings.

D. Provide three (3) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the "Record and Information Booklet" complete with electronic copy as hereinafter specified.

E. All lines (piping) installed under this contract shall be stenciled with "direction of flow" arrows and with stenciled letters naming each pipe and service.

F. Provide at least 8 hours of straight time instruction to the operating personnel. This instruction period shall consist of not less than one (1) consecutive 8-hour day. Time of instruction shall be designated by the Owner. All instruction periods shall be video-taped, DVD or Flash Drive format. Turn two (2) copies to the Owner after successful demonstration and training.

3.14 WALL AND FLOOR PENETRATION:

A. All penetrations of partitions, ceilings, and floors by piping or conduit under Division 22 shall be sealed and caulked airtight for sound and air transfer control and/or fire stopped for fire walls and floors.

3.15 RECORD DRAWINGS:

A. Upon completion of the plumbing installations, the Contractor shall deliver to the Architect one complete set of the plumbing contract drawings and PDF markups on a flash drive, which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings. Additionally the contractor shall provide an electronic copy of the record drawings.

3.16 GUARANTEE:

A. Contractor's attention is directed to guarantee obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of guarantee shall be included in the operations and maintenance manuals.

C. Contractor shall also provide, when due to malfunction, two (2) years free service, from the time of substantial completion by the Owner, to keep the equipment in operating condition. This service shall be rendered upon request when notified of any equipment malfunctions.

D. All refrigeration compressors shall be provided with a five (5) year parts and labor warranty, including replacement of refrigerant.

E. Refer to specific equipment specifications for extended warranties. If the manufacturer does not offer the required warranty, the Contractor shall include in their bid the cost of an extended

warranty (including from an independent service company) to repair and/or replace the equipment (materials and labor) during the extended warranty period.

3.17 LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

C. Provide pressure relief fittings at all grease lubrication locations designed to automatically vent within the range of 1/4 to 1 psi, automatically reset below this range, or another pressure relief range if the preceding differs from the manufacturer's recommended pressure range.

3.18 RECORD AND INFORMATION BOOKLET:

A. The Contractor shall have prepared three (3) copies of the Record and Information Booklet and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three-ring loose-leaf binder similar to "National" No. 3881 with the following title lettered on the front: "Record and Information Booklet (insert name of the project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pull-out.

C. All booklet information shall also be provided in electronic format, PDF files, stored on a CD/ DVD or Flash Drive. Each binder shall contain an envelope sleeve containing the electronic format media (CD's/DVD's or Flash Drives).

D. Provide the following data in the booklet:
   1. Catalog data on each piece of plumbing equipment furnished.
   2. Maintenance operation and lubrication instructions on each piece of equipment furnished.
   3. Complete catalog data on each piece of plumbing equipment furnished, including approved shop drawings.
   4. Manufacturer's and Contractors' guarantees.
   5. Chart form indicating time and type of routine maintenance of plumbing equipment. The chart shall also indicate tag number, model number of equipment, location and service. For replacement items such as filters, indicate type, size and quantity of the replaceable items.
   6. Provide sale and service representatives' names and phone numbers of all equipment and subcontractors.
   7. Catalog data of all equipment valves, etc., which shall include wiring diagrams, parts list and assembly drawing.
   8. Provide valve chart including valve tag number, valve type, valve model number, valve manufacturer, style, service and location, etc., as specified hereinafter.
   9. Provide certification that lead-free and asbestos-free products were provided.
   10. Provide operating curves indicating design and balanced conditions for pumps.
   11. Provide copies of all flushing reports.
   12. Provide copies of all start-up reports.

13. DVD's or Flash Drives of all demonstration and instructional periods.
14. CD's/DVD's or Flash Drives of all drawings.

3.19 TESTS, GENERAL:

A. The entire new plumbing systems shall be tested hydrostatically for a duration of four (4) hours before insulation covering is applied and provided tight under the following gauge pressures:
   1. Domestic Water & Coil Drain Piping: 100 psi
   2. Sanitary & Storm Water Piping: as specified below
   3. Sanitary & Storm Water Piping: as specified below
   4. Natural Gas: 100 psi

B. All storm, waste, vent and water piping shall be tested by the Contractor and approved by the Engineer and local code official before acceptance. All storm, soil, and waste piping, located underground, shall be tested before backfilling. The costs of all equipment required for tests are to be included under the contract price. Refer to paragraph 3.28 for additional information.

C. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest stack above or at the roof. The system shall hold this water for thirty (30) minutes without showing a drop greater than 1". Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure. The pressure shall be maintained for thirty (30) minutes.

D. Upon completion of roughing-in and before setting fixtures, the entire new water piping system shall be tested at a hydrostatic pressure of not less than one hundred (100) pounds per square inch gauge and proved tight at this pressure. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.

E. All testing shall be witnessed by local code official and the Owner. The Contractor shall provide a minimum of 48-hour notice before testing. The Contractor shall coordinate with and get approval from the Owner.

F. Gas Testing:
   1. Before any section of a gas piping system is put into service, it shall be carefully tested to assure that it is gastight. Prior to testing, the system shall be blown out, cleaned, and cleared of all foreign material. Each joint shall be tested by means of an approved gas detector, soap and water, or an equivalent nonflammable solution. Testing shall be completed before any work is covered, enclosed, or concealed. All testing of piping system shall be done with due regard for the safety of employees and the public during the test. All testing and purging shall comply with local utility company requirements. Bulkheads, anchorage and bracing suitably designed to resist test pressures shall be installed if necessary. Oxygen shall not be used as a testing medium.
   2. Pressure Tests: Before appliances are connected, piping systems shall be filled with air or an inert gas and shall withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54 without showing any drop in pressure. Oxygen shall not be used. Pressure shall be measured with a mercury manometer, slope gauge, or an equivalent device so calibrated as to be read in increments of not greater than 0.1 pound. The source of pressure shall be isolated before the pressure tests are made.
   3. Test with Gas: Before turning gas under pressure into any piping, all openings from which gas can escape shall be closed. Immediately after turning on the gas, the piping

system shall be checked for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. All testing shall conform to the requirements of NFPA 54. If leakage is recorded, the gas supply shall be shut off, the leak shall be repaired, and the tests repeated until all leaks have been stopped.

4. Purging: After testing is completed, and before connecting any appliances, all gas piping shall be fully purged. Piping shall not be purged into the combustion chamber of an appliance. The open end of piping systems being purged shall not discharge into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 are followed.

5. Labor, Materials, and Equipment: All labor, materials, and equipment necessary for conducting the testing and purging shall be furnished by the Contractor.

3.20 LINTELS:

A. Under this Section, provide lintels not provided elsewhere which are required for openings for the installation of plumbing work. Lintels shall meet the requirements of the Architectural and Structural Sections and The Architectural Drawings and Specifications.

3.21 EQUIPMENT BY OTHERS

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections.

C. Typical equipment refers to, but is not limited to: Kiln hoods, storage cabinets and all other kitchen equipment.

3.22 FASTENERS:

A. All fasteners located in public space, including classrooms, offices, etc., shall be provided with tamper-proof type fasteners where specifically indicated.

3.23 WIRING DIAGRAMS

A. Obtain and submit wiring diagrams for all equipment provided under this Contract.

B. Wiring diagrams shall be provided with Shop Drawings for similar to, but not limited to, the following:
   1. All equipment.

C. The Contractor shall submit any additional wiring diagrams as requested by the Engineer.

D. Provide wiring diagrams and identify all termination points, connections, and interface points for all major mechanical equipment to the Electrical Contractor and the ATC Subcontractor for coordination.

3.24 BOILER AND PRESSURE VESSELS

A. All boilers and pressure vessels shall be ASME-rated and shall comply with the State of Maryland, latest requirements.

B. Provide all control devices and materials, and install in with ASME CSD-1 controls and safety devices for automatically fired boilers.

3.25 FACTORY START-UP

A. Provide factory authorized start-up service for all plumbing equipment. Coordinate with the Commissioning Agent.

B. Provide one copy of all start-up reports to the Owner and include a copy in the O&M Manual.

C. Tempering Valves: Provide factory-authorized individual to review installation and develop a report to submit to the Engineer. Report submission shall be prior to Engineer's Punch-Out and Demonstration/Training.

D. The Contractor shall be required to start up all systems in an orderly, organized, and coordinated manner to ensure that all systems are functioning as designed. The Contractor shall provide a detailed start-up, testing and demonstration plan for all systems in a coordinated manner that is documented in writing at least forty-five (45) days prior to start-up. Start-up, testing, and demonstration plans shall include detailed point-by-point check list that clearly shows that systems are in face functioning as designed. The A/E shall include modifications to the standard AIA definition of substantial completion to indicate that Mechanical/Electrical Systems are not substantially complete until all systems are started, tested, balanced, and O&M Manuals are received by the Owner. Above listed items must be completed in time to allow for system demonstrations to Owner Personnel with all O&M Manuals in hand at the time of demonstration. Contractors will be required to provide system demonstrations and training for Owner Personnel for each system. At minimum, the Contractors shall provide eight (8) hours of demonstration and eight (8) hours of systems operation training for each system prior to Owner acceptance of any given system.

3.26 PLUMBING INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of plumbing systems, materials, and equipment including, but not limited to, the following:
   1. Coordinate plumbing systems, equipment and materials installation with other building components.
   2. Verify all dimensions by field measurements.
   3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
   4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
   5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing in the building.
   6. Where mounting heights are not detailed, noted, or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
   7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised

service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished space.
10. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of equipment components in accordance with manufacturers' recommendations. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
11. Install access panels or doors where units are concealed behind finished surfaces.
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
13. Install above-ceiling equipment requiring servicing and/or maintenance within 48" of accessible ceilings/access panels.
14. Test and balance the domestic hot water/hot water recirculation system.
15. Where different pipe sizes are indicated on the Drawings, the largest pipe size shall be used for the basis of the Bid.

3.27 SCHEDULING OF WORK AND OUTAGES

A. All required outages shall be coordinated with and approved by the Owner a minimum of fourteen (14) days in advance. Written notice of not less than fourteen (14) calendar days shall precede any outage. The Contractor shall include in their bid outages and/or work in occupied areas to occur during weekends, holidays, or at night. No outages are allowed during school hours.

B. All temporary utilities shall be provided by and paid for by the Contractor. All utilities serving the existing building(s) shall be maintained; or temporary piping, equipment, etc., shall be provided so as not to affect the normal function and operation of the building and its systems. Coordinate these requirements with the Owner.

C. The Contractor shall notify the Owner within 72 hours prior to having the AHJ coming out to witness any/all hydro-static pressure testing, gravity testing of sanitary or storm water piping and testing of all domestic water and gas piping systems. Test results must be provided, no exceptions or the test shall be redone.

3.28 COMMISSIONING:

A. All systems shall be commissioned by an independent Commissioning Agent. Coordinate all commissioning activities and start up services with the Commissioning Agent.

- END OF SECTION 22 05 00

SECTION 22 05 13
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 requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

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

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) 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 of the following, to suit starting torque and requirements of specific motor application:
   1. EMC type.

B. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

C. Motors 1/20 HP and Smaller: Shaded-pole type or ECM type as indicated.

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

PART 3 - EXECUTION (Not Applicable)

- END OF SECTION 22 05 13 -

SECTION 22 05 19
METERS AND GAUGES 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. Filled-system thermometers.
2. Liquid in glass thermometers.
3. Thermowells.
4. Dial-type pressure gauges.
5. Gauge attachments.
6. Test plugs.
7. Test-plug kits.
8. Sight flow indicators.

B. Related Sections:
1. Division 21 fire-suppression piping Sections for fire-protection pressure gauges.
2. Division 22 Section "Facility Water Distribution Piping" for domestic water meters and combined domestic and fire-protection water-service meters outside the building.
3. Division 22 Section " Domestic Water Piping" for water meters inside the building.

1.3 SUBMITTALS

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

B. Product Certificates: For each type of meter and gauge, from manufacturer.

C. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

D. NSF-61 compliance for all products that will come in contact with potable water.

1.4 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of meter and gauge from single source from single manufacturer.

B. NSF Compliance: NSF 61Certified Lead Free for valve metering gauge materials for potable-water service.

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

A. Direct-mounted, metal case, vapor-actuated thermometers.

B. Basis-of-Design Product: subject to compliance with requirements, provide H.O. Trerice No. V80445, or comparable product by one of the following or equal:
   1. Ashcroft, Inc.
   2. Miljoco Corporation.
   3. Weiss Instruments, Inc.

C. Standard: ASME B40.200.

D. Case: Sealed Type, cast aluminum or stainless steel, 4-1/2" nominal diameter.

E. Element: Bourdon tube or other type of pressure element.

F. Movement: Mechanical, dampening type with link to pressure element and connection to pointer.

G. Dial: Nonreflective aluminum with permanently etched scale markings graduated in degrees F.

H. Pointer: Dark-colored metal.

I. Window: Glass.

J. Ring: Stainless steel.

K. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane with locking device; with ASME B1.1 screw threads.

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

M. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial Style, Liquid-in-Glass Thermometers.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide H.O. Trerice Model BX9 Industrial thermometer or comparable product by one of the following:
      a. Ashcroft, Inc.
      b. Miljoco Corporation.
      c. Trerice, H.O. Co.
      d. Weiss Instruments, Inc.
   2. Standard: ASME B40.200.
   3. Case: Cast aluminum 9-inch (229-mm) nominal size unless otherwise indicated.
   4. Case Form: Back angle unless otherwise indicated.
   5. Tube: Glass with magnifying lens and blue or red organic liquid.
   6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in deg F (deg C).
   7. Window: Glass.

8. Stem: Brass adjustable angle, brass stem and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 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: Brass.
4. Material for Use with Steel Piping: Brass.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), 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.

C. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow.

2.4 PRESSURE GAUGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice, Model 600C, or comparable product by one of the following:
   a. Ashcroft Inc.
   b. Ernst Flow Industries.
   c. Miljoco Corporation.
   d. Noshok.
   e. Weiss Instruments, Inc.

2. Standard: ASME B40.100.
3. Case: Liquid-filled, sealed, type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), 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 (kPa).
8. Pointer: Dark-colored metal.
9. Window: Glass.

10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
12. All gauges at pumps shall be liquid filled type.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gauges:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice Industrial, or comparable product by one of the following:
   a. Ashcroft Inc.
   b. Ernst Flow Industries.
   c. Miljoco Corporation.
   d. Noshok.
   e. Weiss Instruments, Inc.

2. Standard: ASME B40.100.
3. Case: Dry type; cast aluminum or drawn steel, 4-1/2-inch (114-mm), nominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), 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 (kPa).
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass threaded needle valve with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

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

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

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 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 300 psig at 250 deg F (2070 kPa at 121 deg C).

F. Core Inserts: EPDM self-sealing rubber.

2.7 TEST-PLUG KITS

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

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, 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- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).

E. Pressure Gauge: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).

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

2.8 SIGHT FLOW INDICATORS

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

1. Archon Industries, Inc.
2. Dwyer Instruments, Inc.
3. Emerson Process Management; Brooks Instrument.
4. Ernst Co., John C., Inc.
5. Ernst Flow Industries.
6. KOBOLD Instruments, Inc. - USA; KOBOLD Messring GmbH.
7. OPW Engineered Systems; a Dover company.
8. Penberthy; A Brand of Tyco Valves & Controls - Prophetstown.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 125 psig (860 kPa).

E. Minimum Temperature Rating: 200 deg F (93 deg C).

F. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

G. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

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 gauges in piping tees with pressure gauge located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gauge 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 gauges 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, liquid filled.

3.2 CONNECTIONS

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

3.3 ADJUSTING

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
   1. Compact, industrial-style, liquid-in-glass type.
   2. Test plug with chlorosulfonated polyethylene synthetic 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 (Minus 20 to plus 50 deg C).

B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F (0 to plus 115 deg C); 30 to 240 deg F and 0 to plus 115 deg C.

3.6 PRESSURE-GAUGE SCHEDULE

A. Pressure gauges at discharge of each water service into building shall be selected so that the thermal readings are at the approximate mid-point and maximum pressures. Do not exceed full scale.

- END OF SECTION 22 05 19 -

SECTION 22 05 23
GENERAL-DUTY 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. Brass ball valves.
2. Bronze ball valves.
3. Bronze lift check valves.
4. Bronze swing check valves.
5. Bronze globe valves.

B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. ASME Compliance:

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

C. NSF Compliance: Maryland HB 372 lead free requirement and NSF 61 Certified Lead Free for all valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4” and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 3 and smaller.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 2 plug valves, for each size square plug-valve head.

5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRASS BALL VALVES

A. Two-Piece, Brass Ball Valves:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
d. Hammond Valve.
e. Jamesbury; a subsidiary of Metso Automation.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. Watts Regulator Company.
i. NIBCO.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel.
j. Port: 2” and Smaller – Full Port, 2-1/2” and Larger Standard Port.

2.3 BRONZE BALL VALVES

A. Two-Piece, Bronze Ball Valves:

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

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
f. NIBCO.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel.
j. Port: 2" and Smaller Full Port, 2-1/2" and Larger Standard Port.

2.4 BRONZE LIFT CHECK VALVES

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

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Milwaukee Valve Company
e. Watts Regulator

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.5 BRONZE SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.

f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.6 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron**,** bronze, or aluminum.

2.7 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.
4. Associated Valve Manufacturer.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to butterfly valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron or cast iron, of type and size required for valve. Include zinc coating.
4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

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.

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.

D. 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 chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

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

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

G. All domestic water valves shall have 2” valve extension on handles.

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. Shutoff Service: Ball valves.
2. Throttling Service: Globe or ball.

3. Pump-Discharge Check Valves:

a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze disc.

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

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded or solder joint valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 4 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port (2” and smaller), standard port (2-1/2” and larger), brass or bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 125, bronze disc.
4. Bronze Globe Valves: Class 125, bronze disc.

- END OF SECTION 22 05 23 -

SECTION 22 05 29
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. Thermal-hanger shield inserts.
4. Fastener systems.
5. Pipe stands.
6. Pipe positioning systems.
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 21 fire-suppression piping Sections for pipe hangers for fire-suppression piping.
3. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

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 SUBMITTALS

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

B. Welding certificates.

1.6 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 cadmium plated or stainless steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-clad hanger, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of cadmium plated or 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 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Clement Support Services.
   2. ERICO International Corporation.
   3. National Pipe Hanger Corporation.
   4. PHS Industries, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa) minimum compressive strength.

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

E. For Clevis: 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.

2.4 FASTENER SYSTEMS

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

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or 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.

2.5 PIPE STANDS

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

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

C. 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. Supports shall be hot-dipped galvanized construction. All fasteners, washers, etc., shall be stainless steel.

2.6 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.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black (painted) 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. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 22 plumbing fixture Sections for requirements for pipe positioning systems for plumbing fixtures.

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

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

J. 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.

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

L. 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.

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

N. Pipe hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer. Do not support all parallel piping from the same bar joist (4” pipe and larger) unless approved by structural engineer.

O. 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.

P. 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 (DN 100) 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 (DN 100) 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 (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.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.

5. Pipes NPS 8 (DN 200) 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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

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 (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.

3.6 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 copper or copper clad attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use painted or galvanized carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications. Use stainless steel pipe hangers and attachments for exterior applications.

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

G. 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. 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.
3. Adjustable Roller Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   a. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   b. 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.

H. 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.

I. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
   2. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

J. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape at the panel point.

   2. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

   3. Side Beam Clamps (MSS Type 27): For bottom of steel I-Beams.

K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   2. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

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

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

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

- END OF SECTION 22 05 29 -

SECTION 22 05 33
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. This 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.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

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

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Raychem, or a comparable product by one of the following:

1. BH Thermal Corporation.
2. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
3. Delta-Therm Corporation.
4. Easy Heat Inc.
5. Thermon Manufacturing Co.

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

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Tinned-copper or stainless-steel braid.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Maximum Operating Temperature: 300 deg F (150 deg C).

H. Capacities and Characteristics:

1. Maximum Heat Output: 3 W/ft. (9.8 W/m), 5 W/ft. (16.4 W/m), or 8 W/ft. (26 W/m), based on pipe size.
2. Piping Diameter: Refer to Drawings.
3. Number of Parallel Cables: Two.
4. Volts: 120V.
5. Phase: Single**.**
6. Hertz: 60.

2.2 CONTROLS

A. Pipe-Mounting Thermostats for Freeze Protection:

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).
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 Division 22 Section "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) 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.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:

1. Piping Systems: Provide self-regulating, parallel-resistance heating cable for condensate drain piping located in refrigerators and freezers.

3.3 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written recommendations using 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 Division 22 Section "Plumbing Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

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

D. Protect installed heating cables, including nonheating leads, from damage.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

1. Test cables for electrical continuity and insulation integrity before energizing.
2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

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

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

- END OF SECTION 22 05 33 -

SECTION 22 05 48
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. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
2. Kinetics Noise Control.

3. Mason Industries.

B. Pads: Arranged 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. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. 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- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with 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- (6-mm-) 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: 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.

F. Elastomeric Hangers: Single or 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.

G. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

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

H. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

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

I. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

J. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 VIBRATION ISOLATION EQUIPMENT BASES

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. Amber/Booth Company, Inc.

2. Kinetics Noise Control.
3. Mason Industries.

C. Steel Base: 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.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. 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.

D. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

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.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. 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.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

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 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 will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

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

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 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.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

- END OF SECTION 22 05 48 -

SECTION 22 05 53
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. Stencils.
5. Valve tags.
6. Warning tags.

1.3 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.

1.4 COORDINATION

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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths 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 based on PM Identification System of the owner, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

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

2.3 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, snap-on semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive (4" and less). For larger pipe (sizes 6" and greater) markers shall be strapped around using nylon ties.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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 1-1/2 inches (38 mm) high.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME (ANSI) A13.1 for piping; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard or metal.
2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, alkyd enamel in colors according to ASME (ANSI) A13.1 unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) black-filled letters for piping system abbreviation and 1/2-inch (13-mm) black-filled numbers, 2-inch diameter.

1. Tag Material: Brass, 19 gauge minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass jack chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches (100 by 178 mm).
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: 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 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 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 with painted, color-coded bands or rectangles, complying with ASME (ANSI) A13.1, on each piping system.

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

C. 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 15 feet along each run.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
8. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner to be easily legible from the floor.
9. For piping less than 3/4 inch, provide permanently legible tag as specified hereinbefore for valve identification.
10. For buried piping, provide 2-inch minimum width with plastic identification/detection tape with metallic core. Install 4 to 6-inches below-grade.

D. Pipe Label Color Schedule:

1. Natural Gas:

a. Background Color: Yellow.
b. Letter Color: Black.

2. Domestic Water Piping:

a. Background Color: Green.
b. Letter Color: White.

3. Sanitary Waste and Storm Drainage Piping:

a. Background Color: Green.
b. Letter Color: White.

3.4 VALVE-TAG INSTALLATION

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

B. Where valves are located above an acoustical ceiling, provide plastic nameplate attached to ceiling grid to identify their location.

C. 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 (50 mm), round.
b. Hot Water: 2 inches (50 mm), round.
c. Natural Gas: 2 inches (50 mm), round.

2. Valve-Tag Color:

a. Cold Water: Natural.
b. Hot Water: Natural.
c. Natural Gas: Natural.

3. Letter Color:

a. Cold Water: Black.
b. Hot Water: Black.
c. Natural Gas: Black.

3.5 WARNING-TAG INSTALLATION

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

3.6 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of plumbing equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Fuel-burning units, including hot water generator units.
2. Pumps, and similar motor-driven units.

B. Install equipment signs with two screws and permanent adhesive on or near each major item of plumbing equipment. Locate signs where accessible and visible.

1. Signs shall have white letter on a red background.
2. Letter Size: 1/2 inch.
3. Nameplate Size: 1/2 inch high x minimum 6 inch length.
4. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
5. Equipment Name Designation: Provide four part label consisting of the following: RCS (Rock Creek School)-(Equipment Symbol)-(Equipment Number)-(Room Number) or as re quired by the Owner.

   Example: Fan Coil "FCU-1.01" located in Movement Room 718 shall be identified: RCS-FCU-1.01-718.

C. Install access panel markers with screws on equipment access panels.

3.7 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches: Use size to Pretensioned pipe markers. Ensure a tight fit.
2. Pipes with OD, Including Insulation, 6 Inches and Larger: Size to Shaped pipe markers. Use match pipe and secure with fasteners.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations.

- END OF SECTION 22 05 53 -

SECTION 22 07 00
PLUMBING 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:

1. Insulation Materials:

   a. Calcium silicate.
   b. Flexible elastomeric.
   c. Mineral fiber.

2. Insulating cements.
3. Adhesives.
4. Mastics.
5. Lagging adhesives.
6. Sealants.
7. Factory-applied jackets.
8. Field-applied fabric-reinforcing mesh.
9. Field-applied cloths.
10. Field-applied jackets.
11. Tapes.
12. Securements.
13. Corner angles.

B. Related Sections include the following:
   1. Division 23 Section "HVAC Insulation."

1.3 SUBMITTALS

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

B. LEED Submittals: Comply with Section 018113.
   1. MR Credit 2: BPDO – Environmental Product Declarations
      a. For pipe insulation, if available: Product specific declaration or industry wide EPD or product specific EPD
   2. MR Credit 4: BPDO – Material Ingredients
      a. For pipe insulation, if available: Materials Ingredient Report
   3. MR Credit 3: BPDO – Sourcing of Raw Materials
      a. For bio-based insulation: Manufacturers letter on company letterhead stating raw material supplier's compliance with Sustainable Agriculture Network's (SAN)

Sustainable Agriculture Standard, including a link to a publicly available document confirming SAN compliance, dated within one year of the LEED project registration. Include statement indicating percentage by weight of the total assembly that is bio-based. Include material cost.

b. For recycled content insulation: Documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include material cost value.

4. EQ Credit 2: Low-Emitting materials

a. For interior wet applied welding cements, adhesives, sealants, paints, coatings: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method V1.1-2010 and VOC content in g/l. Include volume of material applied per product.

C. Shop Drawings:

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 field application for each equipment type.

D. Qualification Data: For qualified Installer.

E. 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.

F. Field quality-control reports.

1.4 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting 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.

1.5 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.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment 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.

1.7 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 Part 3 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. Calcium Silicate:

1. Products: Subject to compliance with requirements, provide the following:

   a. Owens-Corning.
   b. Johns Mansville.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

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

1. Products: Subject to compliance with requirements, provide the following:

a. Johns Mansville.
b. Armacell LLC; AP Armaflex.
c. Aeroflex USA, Inc.; Aerocel.
d. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:
a. Johns Manville; Micro-Lok.
b. Knauf Insulation; 1000(Pipe Insulation.
c. Owens Corning; Max Fiberglass Pipe Insulation.

2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Insulco, Division of MFS, Inc.; Triple I.
b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

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. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Products, Division of ITW; CP-97.
    b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
    c. Marathon Industries, Inc.; 290.

2. Interior wet applied adhesives: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

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

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.
    d. Marathon Industries, Inc.; 225.
    e. Mon-Eco Industries, Inc.; 22-25.

2. Interior wet applied adhesives: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

D. 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 of the following:

    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.
    d. Marathon Industries, Inc.; 225.
    e. Mon-Eco Industries, Inc.; 22-25.

2. Interior wet applied adhesives: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.
    d. Speedline Corporation; Speedline Vinyl Adhesive.

2. Interior wet applied adhesives: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

2.4 MASTICS

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

1. Interior wet applied mastics: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

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

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-35.
   b. Foster Products Corporation, H. B. Fuller Company; 30-90.
   c. ITW TACC, Division of Illinois Tool Works; CB-50.
   d. Marathon Industries, Inc.; 590.
   e. Mon-Eco Industries, Inc.; 55-40.
   f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) 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, 59 percent by volume and 71 percent by weight.
5. Color: White.

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

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-30.
   b. Foster Products Corporation, H. B. Fuller Company; 30-35.
   c. ITW TACC, Division of Illinois Tool Works; CB-25.
   d. Marathon Industries, Inc.; 501.
   e. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

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

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; Encacel.
   b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
   c. Marathon Industries, Inc.; 570.
   d. Mon-Eco Industries, Inc.; 55-70.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) 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, 33 percent by volume and 46 percent by weight.

5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-10.
b. Foster Products Corporation, H. B. Fuller Company; 35-00.
c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
d. Marathon Industries, Inc.; 550.
e. Mon-Eco Industries, Inc.; 55-50.
f. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
4. Solids Content: 63 percent by volume and 73 percent 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. Interior wet applied adhesives: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

2. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-52.
b. Foster Products Corporation, H. B. Fuller Company; 81-42.
c. Marathon Industries, Inc.; 130.
d. Mon-Eco Industries, Inc.; 11-30.
e. Vimasco Corporation; 136.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-76-8.
b. Foster Products Corporation, H. B. Fuller Company; 95-44.
c. Marathon Industries, Inc.; 405.
d. Mon-Eco Industries, Inc.; 44-05.
e. Vimasco Corporation; 750.

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. Interior wet applied sealants: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

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

1. Products: Subject to compliance with requirements, provide one of the following or equal:

   a. Childers Products, Division of ITW; 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 (Minus 40 to plus 121 deg C).
5. Color: White.
6. Interior wet applied sealants: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”

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 MAX: White, all service jacket with a polymer film exterior surface that is smooth durable, cleanable, wrinkle-resistant, resists water staining and does not support mold growth; complying with ASTM C 1136, Type I.
2. ASJ-SSL II: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

   a. Products: Subject to compliance with requirements, provide the following or equal:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

5. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

   a. Products: Subject to compliance with requirements, provide the following or equal:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

6. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

a. Products: Subject to compliance with requirements, provide the following or equal:

1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.8 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

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

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.9 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. Products: Subject to compliance with requirements, provide one of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
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.

5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), 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: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
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.

D. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard; Insulrap No Torch 125.

2.10 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 of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
b. Compac Corp.; 110 and 111.
c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.

d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
b. Compac Corp.; 130.
c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
d. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
b. Compac Corp.; 120.
c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape: White vapor-retarder PVDC tape with acrylic adhesive.

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

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 6 mils ((0.15 mm)).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.11 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing or closed seal.
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with wing or closed seal.
4. 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, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; CWP-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 of the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

c. Spindle: Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) 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. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide one of the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide one 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.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) GEMCO.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

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

      a. C & F Wire.
      b. Childers Products.
      c. PABCO Metals Corporation.
      d. RPR Products, Inc.

2.12 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel accord.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

   1. Verify that systems and equipment 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. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: 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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). 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 between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade 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 equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and 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- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

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 (50 mm) 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 (50 mm).
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 Division 07 Section "Penetration Firestopping"irestopping 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 Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

a. Do not weld anchor pins to ASME-labeled pressure vessels.
b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
d. Do not overcompress insulation during installation.
e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
f. Impale insulation over anchor pins and attach speed washers.

g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.6 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 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. 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 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.

2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

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 block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

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 insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 MINERAL-FIBER INSULATION INSTALLATION

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 (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but 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 (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) 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 (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.11 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two 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 coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect field-insulated equipment, 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(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.13 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Domestic cold-water storage tank insulation shall be the following, of thickness to provide an R-value of 12.5:
1. Mineral-Fiber Board: 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3.14 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 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. Underground piping.

3.15 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. Two-inch (2”) pipe size and Smaller: Insulation shall be the following:
   a. Molded fiberglass 1/2 inch thick.

2. Two-and-one-half-inch (2-1/2”) pipe size and Larger: Insulation shall be the following:
   a. Molded fiberglass 1-inch thick.

3. Half-inch (1/2”) run-out piping: Insulation shall be one of the following:
   a. Molded fiberglass 1/2-inch thick.
   b. Flexible Elastomeric: 1/2 inch (13 mm) thick.

B. Domestic Hot and Recirculated Hot Water:

1. One-and one-quarter-inch (1-1/4”) pipe size and Smaller: Insulation shall be the following:
   a. Molded fiberglass 1-inch thick.

2. One and one-half-inch (1-1/2”) and Larger: Insulation shall be the following:
   a. Molded fiberglass 1-1/2 inch thick.

3. Half-inch (1/2”) run-out piping: Insulation shall be one of the following:
   a. Molded fiberglass 1-inch thick.

C. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be the following:
   a. Molded fiberglass 1-inch thick.

D. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be the following:
   a. Molded fiberglass 1-inch thick.

E. Interior Condensate Drain and Equipment Drain Water below 60 Deg F (16 Deg C):

1. All Pipe Sizes: Insulation shall be the following:
   a. Molded fiberglass 1-inch thick.

F. Exposed Sanitary Drains, domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   1. All Pipe Sizes: Insulation shall be Truebro Lav Guard – ADA approved undersink pipe insulation cover system. Refer to Section 224000 for additional information on protective shielding guards.

G. Floor Drains, Traps, and Sanitary Drain Piping within 10 feet (3m) of drain receiving condensate and equipment drain water below 60 degrees F (16 degrees C):

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-inch (25 mm) thick.

H. Hot Service Drains:
   1. All Pipe Sizes: Insulation shall be the following: Mineral-Fiber, Preformed Pipe, Type I or II: 1-inch (25 mm) thick.

I. Hot Service Vents:
   1. All Pipe Sizes: Insulation shall be the following: Mineral-Fiber, Preformed Pipe, Type I or II: 1-inch (25 mm) thick.

J. Piping with Heat Trace:
   1. All pipe sizes (exterior condensate drain and refrigerator/freezer condensate drain piping): Insulation shall be the following: Mineral-Fiber, Preformed Pipe, Type I or II: 1-inch (25 mm) thick.

3.16 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 material is listed, selection from materials listed is Contractor's option.

C. Equipment, Exposed, up to 48 inches (1200 mm) in Diameter or with Flat Surfaces up to 72 inches (1800 mm):
   1. PVC: 30 mils (0.8 mm) thick.

D. Equipment, Exposed, Larger than 48 inches (1200 mm) in Diameter or with Flat Surfaces Larger than 72 inches (1800 mm):
   1. Aluminum with 0.040 inch (1.0 mm) thick.

E. Piping, Concealed:
   1. None.

F. Piping, Exposed (including mechanical rooms) and/or Heat Traced:
   1. Indoor PVC: 20 mils (0.5 mm) thick, Green with White lettering for identification).
   2. Indoor Student Accessible Areas: Aluminum: 0.040 inch thick.
   3. Exterior – Aluminum: 0.040 inch thick.

- END OF SECTION 22 07 00 -

SECTION 22 11 16
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. Piping Materials.
2. Copper Tube and Fittings
3. Ductile Iron Pipe and Fittings
4. Piping Joining Materials.
5. Transition Fittings
6. Dielectric Fittings
7. Specialty valves.
8. Flexible connectors.
9. Water Meters.

B. Related Section:

1. Division 22 Section "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

1.3 SUBMITTALS

A. Product Data: For the following products:

1. Specialty valves.
2. Piping
3. Transition fittings.
4. Dielectric fittings.
5. Flexible connectors.
6. Backflow preventers and vacuum breakers.
7. Water penetration systems.

B. Water Samples: Specified in "Cleaning" Article.

C. Coordination Drawings: For all piping, draw to 3/8” scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression-water piping.
2. Domestic water piping.
3. HVAC hydronic piping.
4. Equipment.

5. Ductwork.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with State of Maryland HB 372 and NSF 61 for potable domestic water piping and components.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

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.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube Above-Ground: ASTM B 88, Type L water tube, drawn temper.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
5. Press Fittings
   a. Viega ProPress
   b. Nibco
   c. XPress

B. Soft Copper Tube Below Building Slab: ASTM B 88, Type K (ASTM B 88M, Type A) water tube, annealed temper.

1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

2. Press fittings.

2.3 DUCTILE IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.

2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.

   a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
3. Lining: AWWA C104, cement mortar.
4. Gaskets: AWWA C111, rubber.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, galvanized steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 PEX TUBE AND FITTINGS

A. Tube Materials: Aquapex as manufactured by Uponor.

B. PEX tubing shall be ASTM F876 tested and approved for excessive temperature and pressure for 725 hours at 210 degrees F (99 degrees C) @ 150 psi (1035 kPa).

C. PEX tubing shall be manufactured in accordance with ASTM F876, ASTM F877 and CAN/CSA-B137.5. The tube shall be listed to ASTM by an independent third party agency.

D. PEX tubing shall be listed to both NSF/ANSI 14 and 61.

E. PEX tubing shall have Standard Grade hydrostatic design and pressure ratings of 200 F (82 degrees C) at 80 psi (551 kPa), 180 degrees F (82 degrees C) at 100 psi (689 kPA), and 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa). Temperature and pressure ratings shall be issued by the Plastic Pipe Institute (PPI), a division of the Society of the Plastic Industry (SPI).

F. Minimum bend radius for cold bending of the PEX tubing shall not be less than six (6) times the outside diameter. Bends with a radius less than stated shall require the use of a bend support as supplied by tube manufacturer.

G. Fitting Materials: Fittings shall be manufactured of Engineered Polymer (EP). Lead free brass materials are allowed only for transition fittings. Fitting connections shall be made to the requirements of ASTM F1960.
   1. Fittings shall be supplied by the PEX tubing manufacturer.
   2. PEX-a cold expansion type fittings shall be an assembly consisting of insert and PEX-a cold expansion ring.
   3. Polymer Fitting Type: Uponor Engineered Polymer (EP) fittings.
   4. Brass Fitting Type: Uponor lead free brass fittings.

H. ACCESSORIES

1. Tubing Wall Penetration Brackets: Brackets designed for tubing wall membrane penetrations shall be supplied by PEX tubing manufacturer.
   a. Bracket Type: Uponor ProPEX Out-of-the-Wall System.
2. Horizontal Pipe Support Channels: All horizontal pipe supports for PEX sizes 1" and greater shall be galvanized steel channels and self-gripping and be supplied by the PEX tubing manufacturer.
   a. Pipe Support Type: Uponor PEX-a Pipe Support.
3. Riser Clamps: All PEX riser clamps shall be epoxy coated.
4. Copper Stubs: Copper piping with PEX-a connector.

2.6 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 of the following:

   a. Cascade Waterworks Manufacturing.
   b. Dresser, Inc.; Dresser Piping Specialties.
   c. Smith-Blair, Inc; a Sensus company.
   d. Viking Johnson; c/o Mueller Co.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. EPCO Sales, Inc.
   b. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   c. Hart Industries International, Inc.

2. Description:

   a. Factory-fabricated, bolted, companion-flange assembly.
   b. Pressure Rating: 150 psig (1035 kPa).
   c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples:

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

    a. Perfection Corporation; a subsidiary of American Meter Company.
    b. Precision Plumbing Products, Inc.
    c. Victaulic Company.

2. Description:

    a. Electroplated steel nipple complying with ASTM F 1545.
    b. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
    c. End Connections: Male threaded or grooved.
    d. Lining: Inert and noncorrosive, propylene.

D. Dielectric unions and couplings are prohibited.

2.8 FLEXIBLE CONNECTORS

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

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex Pression, Ltd.
4. Flex-Weld, Inc.
5. Hyspan Precision Products, Inc.
6. Mercer Rubber Co.
7. Metraflex, Inc.
8. Proco Products, Inc.
9. Tozen Corporation.
10. Unaflex, Inc.
11. Universal Metal Hose; a Hyspan company
12. Mason Industries.

B. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.9 WATER METERS

A. Displacement-Type Water Meters (1-1/4” and Smaller):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Seametrics
    b. Badger Meter, Inc.
    c. Sensus Metering Systems.
    d. Hersey Meter.

2. Description:

a. Standard: AWWA C700.
b. Pressure Rating: 150-psig (1035-kPa) working pressure.
c. Body Design: Nutating disc; totalization meter.
d. Registration: In gallons or cubic feet as required by utility. In gallons for make-up water and other building sub-metering requirements.
e. Case: Bronze.
f. End Connections: Threaded.
g. Energy Management: Connection to the BACNET (Building Management System).

B. Electromagnetic-Type Water Meters (1-1/2" and Larger):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Seametrics
   b. Badger Meter, Inc.
   c. Sensus Metering Systems.
   d. Hersey Meter.
   e. Onicon.

2. Description:

   a. Standard: AWWA C701.
   b. Pressure Rating: 150-psig (1035-kPa) working pressure.
   c. Body Design: Turbine; totalization meter.
   d. Registration: In gallons or cubic feet as required by utility company. In gallons for make-up water and other building sub-metering requirements.
   e. Case: Stainless Steel.
   f. End Connections for Meters NPS 2 (DN 50) and Smaller: Threaded.
   g. End Connections for Meters NPS 2-1/2 (DN 65) and Larger: Flanged.
   h. Energy Management: Connection to the BACNET Building Management System.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31 Section "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 shutoff valve, hose-end drain valve, strainer, pressure gauge, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gauges for Plumbing Piping" for pressure gauges and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. 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.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping adjacent to equipment and specialties to allow service and maintenance.

L. Install piping to permit valve servicing.

M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

N. Install piping free of sags and bends.

O. Install fittings for changes in direction and branch connections.

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install liquid filled pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22.

R. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22.

S. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22.

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22.

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22.

W. Install underground copper tube and ductile iron pipe in PE encasement according to ASTM A674 or AWWA C105.

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: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: 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. 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.

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

H. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.

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.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, for each branch serving toilet room(s), for each branch pipe serving two or more fixtures, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves for piping NPS 2 (DN 50) and smaller. Use ball valves for piping NPS 2-1/2 (DN 65) and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section.

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install combination balancing/shut-off valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
2. NPS 2 (DN 50) and Larger: Sleeve-type coupling.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples only.

C. Dielectric Fittings for NPS 2-1/2 and larger: Use dielectric flanges only.

3.7 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

3.8 WATER METER INSTALLATION

A. Rough-in domestic water piping and install water meters according to utility company's requirements and/or as required for building sub-metering.

B. Install water meters according to AWWA M6 and/or the utility company's requirements

C. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.

D. Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.

E. Install remote registration system according to standards of utility company and of authorities having jurisdiction.

F. Provide remote reading for integration with the BACNET Building Control System.

3.9 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Feet (30 m) If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) 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 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 (DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 4 (DN 150): 12 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 200): 12 feet (3 m) with 3/4-inch (19-mm) rod.

F. Install supports for vertical copper tubing every 10 feet (3 m).

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1-1/2 (DN 40): 96 inches with 3/8-inch rod.
3. NPS 2 (DN 50): 8 feet with 3/8-inch rod.
4. NPS 2-1/2 (DN 65): 10 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 (DN 100): 14 feet with 5/8-inch rod.
7. NPS 6 (DN 150): 16 feet with 3/4-inch rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 20 feet with 7/8-inch (22-mm) rod.

H. Install supports for vertical steel piping every 15 feet (4.5 m).

I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

J. Hangers shall be connected to top chord panel points at joist locations.

K. Support PVC piping every 4'0" or in accordance with MSS Sp-69 and manufacturers written instructions.

3.10 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow 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 required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
   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 (DN 65) and larger.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

   3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
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 for corrective action required.
7. Testing with air in lieu of water shall be at the Owner's discretion dependent upon weather conditions.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 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 flow of hot water 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.

3.14 CLEANING

A. Clean and disinfect potable and 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 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 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.

   c. Flush system with clean, potable water until chlorine level is <1.0 ppm in water coming from system after the standing time.
   d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
   e. Submit testing results to Architect.

3.15 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. Under-ground, domestic water piping, NPS 1 to NPS 3, shall be the following:

   1. Type K, annealed-temper soft copper tubing, wrought copper fittings and brazed joints

D. Under-building slab, fire-service-main piping, NPS 4 to NPS 12, shall be the following:

   1. Mechanical-joint, ductile-iron pipe; standard-pattern mechanical-joint fittings; and mechanical joints.

E. Above Ground Domestic Water Piping (all sizes)
   1. All aboveground domestic water piping shall be the following
      a. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B) or wrought- copper solder-joint fittings; and soldered joints.

3.16 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

   1. Shutoff Duty: Use ball valves for piping NPS 4 (DN 100) and smaller. Use ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
   2. Throttling Duty: Use ball valves for piping NPS 4 (DN 100) and smaller. Use ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
   3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
   4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

- END OF SECTION 22 11 16 -

SECTION 22 11 19
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. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Balancing valves.
3. Temperature-actuated water mixing valves.
4. Strainers.
5. Hose bibbs.
6. Wall hydrants.
7. Drain valves.
8. Water hammer arresters.
9. Air vents.
10. Trap-seal primer systems.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gauges for Plumbing Piping" for thermometers, pressure gauges, and flow meters in domestic water piping.
2. Division 22 Section "Domestic Water Piping" for water meters.
3. Division 22 Section "Emergency Plumbing Fixtures" for water tempering equipment.
4. Division 22 Section "Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig (860 kPa), unless otherwise indicated.

1.4 SUBMITTALS

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

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
   1. Comply with State of Maryland HB 372 and NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
   2. All components shall be certified as Lead Free in accordance with NSF 61.

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Company.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. Watts Industries, Inc.; Water Products Division.
      e. Zurn Plumbing Products Group; Wilkins Division.
   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), 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 of the following:
      a. MIFAB, Inc.
      b. Watts Industries, Inc.; Water Products Div.
      c. Conbraco Industries, Inc.
      d. Zurn Plumbing Products Group; Wilkins Div.
      e. Josam.
      f. Chicago.

   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: Chrome or nickel plated.

C. Pressure Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Company.
      b. Conbraco Industries, Inc.
      c. Watts Industries, Inc.; Water Products Division.
      d. Zurn Plumbing Products Group; Wilkins Division.
   2. Standard: ASSE 1020.

3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.
5. Accessories: Valves – Ball type, on inlet and outlet.

2.2 BALANCING VALVES

A. Memory-Stop Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Conbraco Industries, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. Watts.
   h. Tour and Anderson.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
4. Size: NPS 2 (DN 50) or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.3 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Individual-Fixture, Water Temperature Limiting Devices:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Watts.
   b. Lawler Manufacturing Company, Inc.
   c. Powers; a Watts Industries Co.

2. Standard: ASSE 1070, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig (860 kPa) 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. Tempered-Water Setting: 105 deg F.
9. Tempered-Water Design Flow Rate: 1.5 gpm, or as indicated on the Drawings.

2.4 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig (860 kPa) minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:

    a. Strainers NPS 2 (DN 50) and Smaller: 0.033 inch (0.84 mm) or 0.062 inch (1.57 mm).
    b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.045 inch (1.14 mm).

6. Drain: Factory-installed, hose-end ball-type drain valve.

2.5 HOSE BIBBS

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

    a. Josam Company.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    d. Watts Drainage Products Inc.
    e. Chicago Faucet.

2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig (860 kPa).
8. Vacuum Breaker: Integral, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Finished Rooms: Operating key.
13. Include operating key with each operating-key hose bib.
14. Include integral wall flange with each chrome- or nickel-plated hose bib.

2.6 WALL HYDRANTS

A. Exterior Nonfreeze Wall Hydrants:
1. Basis of Design Product: Subject to compliance with requirements, provide Josam Model 71300, or comparable product by one of the following:
    a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    b. Watts Drainage Products Inc.
    c. Zurn Plumbing Products.
    d. Woodford Manufacturing Company.

2. Standard: ASME A112.21.3M for exposed-outlet, self-draining wall hydrants.

3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 (DN 20), female/NPS 1" (DN 25) male.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Outlet: Exposed, manual drain type, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
9. Nozzle and Wall-Plate Finish: Satin finish bronze.
10. Operating Keys(s): Two with each wall hydrant.

B. Interior Cold-Water Wall Hydrants:
1. Basis of Design Product: Subject to compliance with requirements, provide Josam Model 71300, or comparable product by one of the following:
   a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   b. Tyler Pipe; Wade Div.
   c. Watts Drainage Products Inc.
   d. Woodford Manufacturing Company.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.
5. Casings and Operating Rods: Of length required to match wall thickness. Include wall clamps.
6. Inlets: NPS 3/4 female, or NPS 1 male (DN 20 or DN 25).
7. Outlet: Concealed.
8. Box: Deep, flush mounting with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Vacuum Breaker: Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052 and with garden-hose thread complying with ASME B1.20.7 on outlet.
11. Operating Keys(s): Two with each wall hydrant.

C. Nonfreeze, Hot- and Cold-Water Wall Hydrants:
1. Basis of Design Product: Subject to compliance with requirements, provide Josam Model 71650, or comparable product by one of the following:
   a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   b. Tyler Pipe; Wade Div.
   c. Watts Drainage Products Inc.
   d. Woodford Manufacturing Company.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.
5. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Vacuum Breaker:

a. Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
b. Garden-hose thread complying with ASME B1.20.7 on outlet.

11. Operating Keys(s): Two with each wall hydrant.

2.7 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 (2760-kPa) minimum CWP.
3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy.
5. Ball: Stainless steel.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.8 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Watts Drainage Products.
   e. Zurn Plumbing Products.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows or copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.9 AIR VENTS

A. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig (1035-kPa) minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 (DN 15) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.10 OUTLET BOXES:

A. CLOTHES WASHER OUTLET BOXES

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

    a. Acorn Engineering Company.
    b. Guy Gray Manufacturing Co., Inc.
    c. Symmons Industries, Inc.
    d. Watts Industries, Inc.; Water Products Div.
    e. Zurn Plumbing Products Group; Light Commercial Operation.

2. Mounting: Recessed.
3. Material and Finish: Enameled-steel or epoxy-painted-steelbox and faceplate.
4. Faucet: Combination, valved fitting or separate hot and cold water, valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Supply Shutoff Fittings: NPS ½ (DN 15) glove, or ball valves and NPS ½ (DN 15) copper, water tubing.
6. Drain: NPS 2 (DN 50) standpipe and P-trap for direct waste connection to drainage piping.
7. Inlet Hoses: Two 60-inch (1500 mm) long, rubber household clothes washer inlet hoses with female, garden-hose-thread coupling. Include rubber washers.
8. Drain Hose: One 48-inch (1200 mm) long, rubber household clothes washer drain hose with hooked end.

B. ICEMAKER OUTLET BOXES:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Acorn Engineering Company.
    b. IPS Corporation.
    c. LSP Products Group, Inc.
    d. Oatey.
    e. Plastic Oddities; a division of Diverse Corporate Technologies.
2. Mounting: Recessed.
3. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS ½ (DN 15) or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS ½ (DN 15) globe or ball valve and NPS ½ (DN 15) copper, water tubing.

2.10 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. PPP Inc.
    b. Sloan**.**

2. Standard: ASSE 1044,
3. Piping: NPS 3/4, ASTM B 88, Type L (DN 20, ASTM B 88M, Type B); copper, water tubing.
4. Cabinet: Surface-mounting steel box with stainless-steel cover.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.

6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: Per job conditions.
8. Size Outlets: NPS 1/2 (DN 15).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. 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 pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.
4. Incoming domestic water service backflow preventer to be 42” off finished floor and 12” clearance on all sides.

C. Install water regulators with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.

D. Install water control valves with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.

E. Install balancing valves in locations where they can easily be adjusted.

F. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install thermometers and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

G. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve, and pump.

H. Install outlet boxes recessed in wall. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

I. Install water hammer arresters in water piping according to PDI-WH 201.

J. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

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. Pressure vacuum breakers.
2. Reduced-pressure-principle backflow preventers.
3. Double-check backflow-prevention assemblies.
4. Reduced-pressure-detector, fire-protection backflow-preventer assemblies.
5. Water pressure-reducing valves.
6. Calibrated balancing valves.
7. Primary, thermostatic, water mixing valves.
8. Primary water tempering 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 Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each double-check backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

- END OF SECTION 22 11 19 -

SECTION 22 13 16
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. This Section includes the following for soil, waste, and vent piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.
3. Encasement for underground metal piping.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.4 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 (30 kPa).

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. LEED Submittals: Comply with Section 08113
1. EQ Credit 2: Low-Emitting materials

a. For interior wet applied solvent cement and adhesive primer: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method V1.1-2010 and VOC content in g/l. Include volume of material applied per product.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. 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; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: (Schedule 40) ASTM D 2665, drain, waste, and vent.

   1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

B. Solvent Cement and Adhesive Primer:

   1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Interior wet applied welding solvent cement and adhesive primer: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”.

2.4 HUB-LESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Heavy-Duty, Husky Type, Shielded, Stainless-Steel Couplings: With stainless-steel shield, 4 stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

a. Available Manufacturers:

1) ANACO.
2) Clamp-All Corp.
3) Ideal Div.; Stant Corp.
4) Mission Rubber Co.
5) Tyler Pipe; Soil Pipe Div.
6) Charlotte.

2.5 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

2. Copper Condensate Drain Piping: Type L, drawn copper tubing, wrought copper fittings and soldered joints.

2.6 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:
a. Fernco, Inc.
b. Logan Clay Products Company (The).
c. NDS, Inc.
d. Plastic Oddities, Inc.

2. Sleeve Materials:
a. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
b. For cast iron soil pipes: ASTM C564 rubber.
c. For dissimilar pipes: ASTM D 1460, elastomeric or rubber sleeve with full length, corrosion-resistant outer shield and corrosion-resistant metal tension band and tightening mechanism on each end.

B. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturers:

a. EBAA Iron Sales, Inc.
b. Romac Industries, Inc.
c. Star Pipe Products; Star Fittings Div.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping shall be the following:
   1. Hubless cast iron soil pipe and fittings; heavy duty (husky) shielded stainless steel couplings and hubless coupling joints.

C. Aboveground, vent piping shall be the following:
   1. Schedule 40 PVC socket fittings and solvent cemented joints.

D. Underground, soil, waste, and vent piping NPS 6 and smaller shall be the following:
   1. Under base bid provide solid wall, Sewer and Drain Series, Schedule 40, PVC pipe; PVC socket fittings; and solvent-cemented joints except for kitchen.
   2. Under add alternate No. 8 provide service class cast iron soil piping with gasketed or caulked joints.
   3. Under base bid provide service class cast iron soil piping with gasketed or caulked joints for all kitchen sanitary lines connected to the grease trap.

E. Above-ground, soil, and waste and vent piping located over the kitchen, cafeteria/dining area (including ancillary spaces) and other food preparation/eating areas shall be the following:
   1. Copper DWV tube, copper drainage fittings and soldered joints.

F. All Condensate Drain Piping:
   1. Schedule 40, PVC pipe, PVC socket fittings and solvent cemented joints.

3.3 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

C. 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."

D. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Do not use double wye fittings or tee wyes on main sanitary lines. All branch fittings. Use long-turn, double

Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

E. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

F. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

G. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

H. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.

I. Install underground PVC soil and waste drainage piping according to ASTM D 2321.

J. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

C. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 VALVE INSTALLATION

A. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

B. Backwater Valves: Install backwater valves in piping subject to sewage backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated. Provide full-sized manhole to grade/finished floor.
2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

E. 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 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.

2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

H. Install supports for vertical copper tubing every 10 feet (3 m).

I. Support piping and tubing not listed above according to MSS SP-69 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 drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage 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 drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

3.8 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 drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. 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. 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 (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. 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.
7. Submit test reports to Architect.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains 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.

- END OF SECTION 22 13 16 -

SECTION 22 13 19
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. This Section includes the following sanitary drainage piping specialties:

1. Backwater valves.
2. Cleanouts.
3. Floor drains.
4. Trench drains.
5. Roof flashing assemblies.
6. Through-penetration firestop assemblies.
7. Miscellaneous sanitary drainage piping specialties.
8. Flashing materials.

B. Related Sections include the following:

1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:

1. Drains.

2. Backwater valves.

3. Solids Interceptors.

1.5 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

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 NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.6 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 size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.

   2. Standard: ASME A112.14.1.
   3. Size: Same as connected piping.
   4. Body: Cast iron.
   5. Cover: Cast iron with bolted access check valve.
   6. End Connections: Hubless.
   7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
   8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Horizontal, PVC Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Rectorseal or as approved equal.

2. Size: Same as connected piping.
3. Body: PVC.
4. Cover: PVC with screwed access to check valve.
5. End Connections: Glued.
6. Type Check Valve: Removable, PVC, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
7. Extension: PVC, soil-pipe extension to field-installed cleanout at floor.

C. Drain-Outlet Backwater Valves:

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. Josam Company; Josam Div.
   b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

3. Size: Same as floor drain outlet.
4. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
5. Check Valve: Removable ball float.
6. Inlet: Threaded.
7. Outlet: Threaded or spigot.

2.2 CLEANOUTS

A. Exposed Metal Cleanouts – Unfinished areas:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4228 Series or a comparable product by one of the following:

   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
   g. Josam Company; Blucher-Josam Div.

2. Standard: ASME A112.3.1 for stainless steel for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Stainless-steel tee with side cleanout as required to match connected piping.
5. Closure: Countersunk brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless-steel plug with seal.

B. Metal Floor Cleanouts:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Series 4188C (terrazzo-recessed); Series 4168C (composition tile – recessed); Series 4048C (ceramic tile – non-recessed) and Series 4026C-Y (carpet with clean-out marker) or a comparable product by one of the following:

    a. Josam Company; Josam Div.
    b. MIFAB, Inc.
    c. Tyler Pipe; Wade Div.
    d. Watts Drainage Products Inc.
    e. Zurn Plumbing Products Group.

2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round, Square, or as determined by floor type.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Wall Cleanouts:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Series 5432 (unfinished areas, Series 4558 (plaster/drywall) and Series 4532 (tile/CMU) or a comparable product by one of the following:

    a. Josam Company; Josam Div.
    b. MIFAB, Inc.
    c. Tyler Pipe; Wade Div.
    d. Watts Drainage Products Inc.
    e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Square, stainless-steel wall-installation frame and cover. Refer to Series type.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains – FD-A:
1. Basis-of-Design Product: Subject to compliance with requirements, provide J. R. Smith Series 2230 or a comparable product by one of the following:
    a. Josam Company; Josam Div.
    b. MIFAB, Inc.
    c. Tyler Pipe; Wade Div.
    d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Not required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Not required.
11. Sediment Bucket: Slotted sediment bucket.
12. Top or Strainer Material: Galvanized cast iron.
13. Top Shape: Round.
14. Dimensions of Top or Strainer: 12" Round**.**
15. Top Loading Classification: Medium Duty.
16. Funnel: Required, where receiving piped waste.
17. Inlet Fitting:
    a. In proximity to flushometer – Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
    b. No proximity to flushometer – Gray iron, with threaded inlet and threaded or spigot outlet
18. Trap Material: Cast iron.
19. Trap Pattern: Deep-seal P-trap.
20. Trap Features:
    a. In proximity to flushometer – Trap-seal primer valve connection.
    b. No proximity to flushometer – Trap-Guard.

B. Cast-Iron Floor Drains – FD-B:
1. Basis-of-Design Product: Subject to compliance with requirements, provide J. R. Smith Series 2005 or a comparable product by one of the following:
    a. Josam Company; Josam Div.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    d. Tyler Pipe; Wade Div.
    e. Watts Drainage Products Inc.
    f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Not required.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Nickel bronze.
13. Top of Body and Strainer Finish: Nickel bronze.
14. Top Shape: Round; or square where installed in tile floors.
15. Dimensions of Top or Strainer:
16. Funnel: Not required.
17. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet.
18. Trap Material: Not required.
19. Trap Pattern: Deep-seal P-trap.
20. Trap Features: Trap-Guard.

C. Cast-Iron Floor Drains – FS:

1. Basis-of-Design Product: Subject to compliance with requirements, provide J. R. Smith Series 3150Y or a comparable product by one of the following:
   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3.
3. Pattern: Floor sink sanitary drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel.
11. Sediment Bucket: Required, aluminum slotted sediment bucket.
12. Top or Strainer Material: Nickel bronze.
13. Top of Body and Strainer Finish: Nickel bronze.
14. Top Shape: Square.
15. Dimensions of Top or Strainer: 12-1/2-inch top nickel bronze rim with 1/2 grate. Eight-inch deep receptor. Coordinate requirements with the food service contractor and authorities having jurisdiction.
16. Funnel: Not required.
17. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet.
18. Trap Material: Not required.
19. Trap Pattern: Deep-seal P-trap.
20. Trap Features: Trap-Guard.

2.4 TRENCH DRAIN – TD-A

A. Plastic Channel Drainage Systems:

1. Basis-of-Design Product: Subject to compliance with requirements, provide J.R. Smith Enviro-Flo Series 9930 with load Class A light Duty Grate Series 9870-451-SSPA, or a comparable product by one of the following:
   a. Zurn Plumbing Products Group; Flo-Thru Operation.
   b. Josam Company.
2. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
   a. Channel Sections: Interlocking-joint, HDPE or PE, modular units, with end caps. Include flat, rounded, or inclined bottom, with level invert and with outlets in number, sizes, and locations indicated. Dimensions: 4 inches (102 mm) wide. Include number of units required to form total lengths indicated.
   b. Grates: With perforations and widths and thickness that fit recesses in channel sections. Material: Perforated stainless steel with quick-lock assembly.
   c. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
   d. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.5 ROOF FLASHING ASSEMBLIES

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

      a. Acorn Engineering Company; Elmdor/Stoneman Div.
      b. Thaler Metal Industries Ltd.
      c. All American Metal Products, Inc.

B. Description: EPDM base seal and skirt extending at least 18 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting. Provide 20-year warranty against leaks, condensation, and defects in materials and/or manufacturing.

C. Roof flashing shall be installed by the Roofing Contractor.

2.6 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

   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. ProSet Systems Inc.

   2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
   3. Size: Same as connected soil, waste, or vent stack.
   4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
   5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
   6. Special Coating: Corrosion resistant on interior of fittings.

2.7 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains – (OHD):

   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.
   3. Open hub drain shall be Josam 67100A Series coated cast iron with ball float, 1-1/2” trap priming connection, or comparable product of J.R. Smith, Zurn, or Wade.
   4. Provide condensate piping and drip funnel where receiving piped condensate.

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 (DN 50): 4-inch- (100-mm-) minimum water seal.
b. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

C. Floor-Drain, Trap-Guard:

1. Description: Trap Guard by Provent Systems, Elastomeric Material, Installs inside drain.
2. Size: Same as floor drain outlet. Refer to manufacture for sizing.

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 (51 mm) 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. Expansion Joints:

1. Standard: ASME A112.21.2M.
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.

H. Vandal Proof Hooded Vent Cap:

1. Description: Galvanized cast iron body and hooded dome cap with vandal-proof securing device.
2. Size: Same as vent piping.
3. Manufacturer: Zurn Z193 or as approved equal of Josam or Jay R. Smith.

I. Odor Reducing Vent Cap:

1. Description: ABS DWV body and PVC hooded dome cap with vapor phase virgin pelletized activated carbon in fiberglass mesh replaceable bag.
2. Size: Same as vent piping.
3. Manufacturer: Odorhog

2.8 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm) thickness.
2. Vent Pipe Flashing: 8 oz./sq. ft. (2.5 kg/sq. m or 0.27-mm) thickness.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

C. 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 (DN 100). Use NPS 4 (DN 100) 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 (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. 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. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
5. For floor drains in proximity to flushometers, provide trap-seal primer valve connection.

6. For floor drains not in proximity to flushometers, provide Provent Trap-Guard.

G. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.

H. Assemble and install ASME A112.3.1, stainless-steel channel drainage systems according to ASME A112.3.1. Install on support devices so that top will be flush with surface.

I. Assemble non-ASME A112.3.1, stainless-steel channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

J. Assemble FRP channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

K. Assemble plastic channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

L. Install fixture air-admittance valves on fixture drain piping.

M. Install stack air-admittance valves at top of stack vent and vent stack piping.

N. Install air-admittance-valve wall boxes recessed in wall. Confirm use and location with engineer prior to installation.

O. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

P. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

Q. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

R. Assemble open drain fittings and install with top of hub 2 inches (51 mm) above floor.

S. Install deep-seal traps on floor drains and other waste outlets.

T. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

U. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

V. Install vent caps on each vent pipe passing through roof. Install odor reducing vent caps on all kitchen vent pipes and any vent pipes located within 20 feet of an AHU intake.

W. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch (25-mm) clearance between vent pipe and roof substrate.

X. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

Y. Install wood-blocking reinforcement for wall-mounting-type specialties.

Z. Install odor reducing vent caps when plumbing vent terminations are within 25’ 0” of any intake louver or vent.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. 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. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Copper Sheets: Solder joints of copper sheets.

B. 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 (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Solids interceptors.

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 Division 22 Section "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

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

3.6 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

- END OF SECTION 22 13 19 -

SECTION 22 14 13
FACILITY STORM DRAINAGE 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. This Section includes the following storm drainage piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.

B. Related Sections include the following:

1. Division 22 Section "Sump Pumps."

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. LLDPE: Linear, low-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PVC: Polyvinyl chloride plastic.

E. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water (30 kPa).
2. Storm Drainage, Force-Main Piping: 50 psig (345 kPa).

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. LEED Submittals: Comply with Section 08113
1. EQ Credit 2: Low-Emitting materials

a. For interior wet applied solvent cement and adhesive primer: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method V1.1-2010 and VOC content in g/l. Include volume of material applied per product.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Schedule 40 Pipe: ASTM D 2665, drain, waste, and vent.

B. Solvent Cement and Adhesive Primer:

   1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Interior wet applied welding solvent cement and adhesive primer: Comply with low-emitting requirements in Division 01, Section “Sustainable Design Requirements-LEED”.

2.4 HUBLESS CAST IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

    a. Available Manufacturers:

        1) ANACO – Husky Series 4000, 4 band.
        2) Clamp-All Corp.
        3) Ideal Div.; Stant Corp.
        4) Mission Rubber Co.
        5) Tyler Pipe; Soil Pipe Div.
        6) Charlotte.

2.5 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

1. Copper Drainage Fittings: ASME B16.23, cast-copper or ASME B16.29, wrought-copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

C. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

2.6 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

    a. Dallas Specialty & Mfg. Co.
    b. Fernco, Inc.
    c. Logan Clay Products Company (The).

2. Sleeve Materials:
    a. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
    b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

    a. Cascade Waterworks Mfg. Co.
    b. Mission Rubber Co.

C. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.

1. Manufacturers:

    a. Cascade Waterworks Mfg. Co.
    b. Dresser, Inc.; DMD Div.
    c. EBAA Iron Sales, Inc.
    d. Ford Meter Box Company, Inc. (The); Pipe Products Div.
    e. JCM Industries, Inc.
    f. Romac Industries, Inc.
    g. Smith-Blair, Inc.
    h. Viking Johnson.
2. Gasket Material: Natural or synthetic rubber.
3. Metal Component Finish: Corrosion-resistant coating or material.

D. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturers:

    a. EBAA Iron Sales, Inc.
    b. Romac Industries, Inc.
    c. Star Pipe Products; Star Fittings Div.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm drainage piping shall be the following:
1. Hubless cast iron soil pipe and fittings; heavy duty (husky) shielded stainless steel couplings and hubless coupling joints.
2. Dissimilar pipe material couplings: Rigid, unshielded non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Underground storm drainage piping shall be the following:
1. Solid wall PVC schedule 40 pipe, PVC socket fittings, and solvent-cemented joints.

D. Aboveground storm drainage force mains shall be the following:

1. Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

E. Aboveground storm drainage above all kitchen, cafeteria, dining and food preparation/storage areas:

1. Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

3.3 PIPING INSTALLATION

A. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Drainage."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."

D. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

F. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

G. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

H. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 2 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

I. Install force mains at elevations indicated.

J. Install PVC storm drainage piping according to ASTM D 2665.

K. Install underground PVC storm drainage piping according to ASTM D 2321.

L. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

M. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Common Work Results for Plumbing."

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Common Work Results for Plumbing."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Common Work Results for Plumbing."

P. Install cast iron storm drainage piping for all above ground locations.

Q. After pressure tests are complete, all storm water piping 3” and larger located under slab will need to be videotaped by a third party to the first manhole or clean-out located outside of the building. The owner will need to be notified 24 hours prior to the test. A copy of the video is to be delivered to the owner.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

C. Hubless cast iron soil piping coupled joints; Join according to CISPI 310 and CISPI’s “Cast Iron Soil Pipe and fittings Handbook” for hubless-coupling joints.

D. Soldered joints: Use ASTM B 813, water flushable, lead-free flux; ASTM B32, lead-free alloy solder; and ASTM B828 procedure, unless otherwise indicated.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sump pump discharge.

1. Install full-port ball valve for piping NPS 2 (DN 50) and smaller.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Backwater valve are specified in Division 22 Section "Storm Drainage Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

E. 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 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
6. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

H. Install supports for vertical copper tubing every 10 feet (3 m).

I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

D. Connect force-main piping to the following:
   1. Sump Pumps: To sump pump discharge.

3.8 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.
   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 storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   5. Prepare reports for tests and required corrective action.
   6. Submit testing reports to Architect.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains 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.

- END OF SECTION 22 14 13 –

SECTION 22 14 23
STORM DRAINAGE 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. Roof drains.
2. Miscellaneous storm drainage piping specialties.
3. Cleanouts.
4. Backwater valves.
5. Trench drains.
6. Through-penetration firestop assemblies.
7. Flashing materials.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains: RD

1. Manufacturers: Basis of Design Product: Subject to compliance with requirements, provide Jay R. Smith Series 1015 or comparable product by one of the following:

   a. Josam Company.
   b. Tyler Pipe; Wade Div.
   c. Zurn Plumbing Products.

2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 15-1/4” diameter.

5. Combination Flashing Ring and Gravel Stop: Required.
6. Flow-Control Weirs: Not required.
7. Outlet: Bottom.
8. Extension Collars: Required.
9. Underdeck Clamp: Required.
10. Expansion Joint: Not required.
11. Sump Receiver Plate: Required.
12. Dome Material: Galvanized cast iron.
13. Perforated Gravel Guard: Not Required.
14. Vandal-Proof Dome: Required.
15. Water Dam: Not required.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:

1. Description: Bronze body with stainless steel screen and threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.
3. JR Smith FIG 1770 or equal

B. Downspout Adaptors:

1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
2. Size: Inlet size to match parapet drain outlet.

C. Downspout Boots:

1. Description: Manufactured, ASTM A 48/A 48M, paintable galvanized cast iron, with strap or ears for attaching to building and cleanout; NPS 4 (DN 100) outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 (DN 100) outlet.
3. JR Smith FIG 1780

2.3 CLEANOUTS

A. Floor Cleanouts:

1. Basis of Design Product: Subject to the compliance with requirements, provide Jay R. Smith Series 4188C (terrazzo-recessed), Series 4168C (composition tile –recessed), Series 4048C (Ceramic tile –Non-recessed), and Series 40266-Y (carpet with clean-out marker0 or comparable products of one of the following:

   a. Josam Company.
   b. Smith, Jay R. Mfg. Co.
   c. Mifab, Inc..
   d. Zurn Plumbing Products Group; Specification Drainage Operation.
   e. Wade.
   f. Watts Water Technologies, Inc.

2. Standard: ASME A112.36.2M, cast iron soil pipe with cast iron ferrule.
3. Size: Same as connected branch.

4. Type: Cast iron soil pipe with cast iron ferrule.
5. Body or Ferrule Material: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round or square as determined by floor type.
12. Top-Loading Classification: Light Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees :

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

    a. Josam Company.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.
    d. Watts Water Technologies, Inc.
    e. Zurn Plumbing Products Group; Specification Drainage Operation.
    f. Wade.

2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Basis of Design Product: Subject to compliance with requirements, provide Jay R. Smith Series 5432 (unfinished areas), Series 4558 plaster/drywall) and Series 4532 (tile and CMU) or comparable product of one of the following:

    a. Josam Company.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.
    d. Wade.
    e. Watts Water Technologies, Inc.
    f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure: Countersunk brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw. Refer to Series type.
8. Wall Access: Square stainless steel wall installation frame and cover.

2.4 BACKWATER VALVES

A. Cast-Iron, Horizontal Backwater Valves :

1. Basis of Design Product: Subject to compliance with requirements, provide Jay R. Smith Series 7022S or comparable product of one of the following:

   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.14.1, for backwater valves.
3. Size: Same as connected piping.
4. Body Material: Cast iron.
5. Cover: Cast iron with bolted access check valve.
6. End Connections: hubless.
7. Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
8. Extension: ASTM A 74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Horizontal, PVC Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Rectorseal or as approved equal.

2. Size: Same as connected piping.
3. Body: PVC.
4. Cover: PVC with screwed access to check valve.
5. End Connections: Glued.
6. Type Check Valve: Removable, PVC, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
7. Extension: PVC, soil-pipe extension to field-installed cleanout at floor.

C. Cast-Iron, Drain-Outlet Backwater Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 7080 Series or comparable product by one of the following:

   a. Josam Company.
   b. Smith, Jay R. Mfg. Co.
   c. Watts Water Technologies, Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Size: Same as floor drain or no huboutlet.
3. Body Material: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

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

   a. ProSet Systems Inc.

2. Standard: ASTM E 814, for through-penetration firestop assemblies.
3. Certification and Listing: Intertek Testing Service NA for through-penetration firestop assemblies.
4. Size: Same as connected pipe.
5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Special Coating: Corrosion resistant on interior of fittings.

2.6 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 1203/sq.ft.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40 mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07 Sections.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.
4. Coordinate installation with the Roofing Contractor.
5. Roof drain hardware shall be 316 stainless steel cap bolts w/ 316 indicating stamp

6. All roof drains shall be insulated

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install downspout boots at grade with top a minimum of 18 inches (Refer to Architectural Drawings) above grade. Secure to building wall.

D. Install conductor nozzles at exposed end of conductors where they spill onto grade.

E. Install cleanouts in aboveground piping and building drain piping according to the International Plumbing Code, and where indicated.

1. Use cleanouts the same size as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install horizontal backwater valves in floor with cover flush with floor.

I. Install drain-outlet backwater valves in outlet of drains.

J. Install test tees in vertical conductors and near floor.

K. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

L. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.

M. Assemble channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

N. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

O. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. For roof drains, the first pipe joint and the connection to the roof drain shall be lead and brown oil oakum. All joints thereafter shall be heavy duty shielded no-hub bands. Provide a clevis hanger within 12 inches of the first elbow coming from the roof drain connection.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. (30-kg/sq. m) lead sheets. Solder joints of 4.0-lb/sq. ft. (20-kg/sq. m) lead sheets, 0.0625-inch (1.6-mm) thickness or thinner.

B. 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 the pipe size, with a minimum length of 10 inches (250 mm) and with skirt or flange extending at least 8 inches (200 mm) around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

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.

3.5 TESTING

A. Perform water tests on roof drain assemblies, including leader piping, and on gutter assemblies and scuppers. Plug roof drain bowl, and using 3/4-inch garden hose, fill sump area and bowl with water. Perform visual inspection below roof decking after thirty minutes. Then run water into the drainage components for thirty minutes. Inspect all drainage components for leakage and repair as required. If repair is needed to fix leaks, this shall be performed at no cost to owner. Owner shall be notified 14 days in advance when testing is to take place and shall be present to witness testing, without exception, or testing shall be re-done.

- END OF SECTION 22 14 23 -

SECTION 22 14 29
SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Submersible sump pumps and controls.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.4 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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal Sump Pumps:
1. Manufacturers: Subject to compliance with requirements, provide Stancor Oil-minder or as approved equal by one of the following:
a. Barnes; Crane Pumps & Systems.
b. Bell & Gossett Domestic Pump; ITT Corporation.
c. Flo Fab inc.

d. Goulds Pumps; ITT Corporation.
e. Grundfos Pumps Corp.
f. Liberty Pumps.
g. Little Giant Pump Co.
h. Pentair Pump Group; Myers.
i. Sta-Rite Industries, Inc.
j. Weil Pump Company, Inc.
k. Zoeller Company.

2. Description: Factory-assembled and -tested sump-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron semiopen design for clear wastewater handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
7. Seal: Mechanical.
8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   a. Motor Housing Fluid: Oil.
9. Controls:
   a. Enclosure: NEMA 250, Type 4X; wall-mounted.
   b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
   c. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   d. Oil Control and Monitor System: The oil control system shall meet the requirements of ASME A17.1 allowing water to be pumped from elevator pits and preventing oil from being pumped.
10. Control-Interface Features:
    a. Remote Alarm Contacts: For remote alarm interface with the building control and monitoring system.
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
       1) On-off status of pump.
       2) Alarm status.
11. Control System:
    a. The Control System shall have a local and remote audio and visual warning system for hydraulic oil spill alert, high liquid condition, and high amperage. Provide a remote alarm contact and interlock to the Building Energy Management System. Coordinate requirements with EMS contractor.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and filling are specified in Division 31 Section "Earth Moving."

3.2 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.3 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Section "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

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. Tests and Inspections:
   1. Perform each visual and mechanical inspection.
   2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

- END OF SECTION 22 14 29 -

SECTION 22 34 00
FUEL-FIRED, DOMESTIC-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. Commercial, gas-fired, high-efficiency, condensing, storage, domestic-water heaters.
2. Domestic-water heater accessories.

B. Related Sections:

1. Section 221116 "Domestic Water Piping."
2. Section 226323 “Facility Natural Gas Piping.”

1.3 ACTION SUBMITTALS

A. Product Data: 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. Product Certificates: For commercial, gas-fired domestic-water heater, from manufacturer.

B. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-fired, domestic-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: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.

C. ASME Compliance:
   1. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV, Part HLW.

D. ANSI compliance: Follow safety and construction requirements of ANSI Z21.10.

E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

F. Intertek/ETL/CETL listing: Safety Standard UL 795 “Commercial-Industrial Gas Heating Equipment.”

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.8 WARRANTY

A. Special Warranty: Manufacturer and/or Contractor agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period. Provide warranty letter in submittal.

   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. Gas-Fired, Storage, Domestic-Water Heaters:

         1) Storage Tank, Heating surfaces, and combustion chamber: Ten (10) years non-prorated.
         2) Burner, Controls and Other Components: Five (5) years.

b. Compression Tanks: Five (5) years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Gas-Fired, Condensing, Power-vent, High-Efficiency, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide basis-of-design product by:

   a. PVI Industries, LLC.- Conquest
   b. Hubbell
   c. Bradford White

2. Standard: ANSI Z21.10.3/CSA 4.3.
3. Description: Burner design/construction to provide 94 percent combustion efficiency at optimum operating conditions, tested to ANSI Z21.10.3.
4. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating. ASME stamped test pressure: 225 psig (1550-kPa)

   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

      1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

   b. Lining: Electroless Nickel (EN) plated complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets. Additional protection may be provided by high-dielectric-strength polymer overcoat.

5. Factory-Installed Storage-Tank Appurtenances:

   a. Anode Rod: Replaceable magnesium.
   b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   c. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
   d. Jacket: Steel with industrial-grade finish.
   e. Burner: Comply with UL 795 or approved testing agency requirements for natural or LP gas-fired, high-efficiency, fan-assisted burner, with gas-train meeting CSD-1 requirement.
   f. Temperature Control: Adjustable thermostat immersion type.
   g. Safety Controls: Automatic, high-temperature-limit (immersion type thermostat) and low-water cutoff devices; electronic flame monitoring.
   h. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

i. Tank Circulator: automatic intermittent pump operation.

6. Electronic controller with digital readout display mounted on heater casing, interface with the building EMS.
7. Special Requirements: NSF 5 construction.
8. Induced Draft Blower, and vent termination caps for direct air intake and for exhaust vent.
9. Stack Temperature Limiting Device.
10. Condensate Neutralization System with flue gas trap.
11. Factory-authorized startup.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water ASME Compression Tanks:

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

   a. AMTROL Inc.
   b. Honeywell International Inc.
   c. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
   d. State Industries.
   e. Taco, Inc.
   f. Wessel

2. Description: ASME rated and certified steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:

   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.

4. Capacity and Characteristics:

   a. Working-Pressure Rating: 150 psig (1035 kPa).
   b. Capacity Acceptable: Refer to Drawings.

B. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball- or butterfly-type shutoff valves to isolate each domestic-water heater and calibrated balancing valves to provide balanced flow through each domestic-water heater.

1. Comply with requirements for ball- or butterfly-type, shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
2. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."

C. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.

D. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 1-psig (6.9-kPa) pressure rating as required to match gas supply.

E. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.

F. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

1. ANSI Z21.22/CSA 4.4-M.

G. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

2.3 WATER HEATER TRIM

A. As a minimum, the heater will be equipped with the following:

1. electronic flame monitoring
2. an immersion operating thermostat
3. an immersion temperature limiting device
4. an ASME- or AGA-rated temperature and pressure relief valve

B. Operating and safety controls shall meet the requirements of UL 795, FM and CSD-1.

C. The water heater shall employ an electronic operating control with digital temperature readout. Operator shall be capable of connecting to a building automation system through serial connection using Modbus RTU protocol.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. 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 017700 " Closeout Procedures" for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 APPLICATIONS AND PERMITS

A. Contractor shall obtain required state permits, provide permit documentation, and pay all applicable permit fees. Owner and Architect will assist in providing required supplemental information for the Contractor to complete permit documentation.

3.2 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Maintain manufacturer's recommended clearance requirements.
2. Arrange units so controls and devices that require servicing are accessible.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearance requirements. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

C. Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install the manufacturer supplied gas train and install gas shutoff valves on gas supply piping.
2. Install gas pressure regulators on gas supplies to the gas-trains inlet.
3. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves.

D. Install combination temperature-and-pressure relief valves on storage tanks per manufacturer instructions. Use relief valves with sensing elements that extend into tanks. Extend water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain. Floor drain to be located within 4 inches of the edge of the housekeeping pad.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Install acid drain piping from stack condensate neutralization system to spill over floor drain.

G. Install thermometer on inlet and outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Division 22 Section "Meters and Gages for Plumbing Piping."

H. Fill domestic-water heaters with water.

I. Charge domestic-water compression tank with air.

3.3 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for gas piping specified in Section 226323 "Facility Natural-Gas Piping."

C. Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

E. Pipe all water heater/flue drains through condensate neutralizer with lime chips.

3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.5 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. 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 017000 "Execution and Closeout Requirements".

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, domestic-water heaters.

- END OF SECTION 22 34 00 -

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:

1. Lavatory Faucets.
2. Sink Faucets.
3. Showers Faucets.
4. Flushometers.
5. Toilet seats.
6. Protective shielding guards.
7. Fixture supports.
8. Interceptors.
9. Water closets.
10. Urinals.
11. Lavatories.
12. Mop sinks.
13. Commercial sinks.
14. Supply Boxes.
15. Dishwasher air gap fittings.

B. Related Sections include the following:

1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
3. Division 22 Section "Water Coolers."

1.2 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.3 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. LEED Submittals: Comply with Section 08113.
   1. Water efficiency prerequisite 2: Indoor water use reduction
      a. For water closet and urinal documentation indicating flush rate in gallons per flush (GPF).
         1) Include documentation indicating Water Sense Label
      b. For faucets, aerators, and showerhead, documentation indicating flow rate in gallons per minute (GPM).
   2. MR Credit 2: BPDO – Environmental Product Declarations
      a. For plumbing fixtures, if available: Product specific declaration or industry wide EPD or product specific EPD
   3. MR Credit 4: BPDO – Material Ingredients
      a. For plumbing fixtures, if available: Materials Ingredient Report

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Enameled, cast-iron fixtures: ASME A112.19.1M.
   2. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
   3. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
   4. Vitreous-China Fixtures: ASME A112.19.2M.
   5. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

   1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME.A112.18.3M.
   2. Faucets: ASME A112.18.1.
   3. Hose-Connection Vacuum Breakers: ASSE 1011.
   4. Hose-Coupling Threads: ASME B1.20.7.
   5. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   6. NSF Potable-Water Materials: NSF 61.
   7. Pipe Threads: ASME B1.20.1.
   8. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   9. Supply Fittings: ASME A112.18.1.
   10. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for shower faucets:

   1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
   2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
   3. Faucets: ASME A112.18.1.
   4. Hand-Held Showers: ASSE 1014.
   5. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
   6. Hose Coupling Threads: ASME B1.20.7.
   7. Manual-Control Antiscald Faucets: ASTM F 444.
   8. Pipe Threads: ASME B1.20.1.
   9. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
   10. Thermostatic-Control Antiscald Faucets: ASTM F444 and ASSE 1016.

J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1.
   3. Dishwasher Air-Gap Fittings: ASSE 1021.
   4. Manual-Operation Flushometers: ASSE 1037.
   5. Plastic Tubular Fittings: ASTM F 409.
   6. Brass Waste Fittings: ASME A112.18.2.
   7. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

K. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Disposers: ASSE 1008 and UL 430.
   2. Dishwasher Air Gap Fittings: ASSE 1021.
   3. Flexible Water Connectors: ASME A112.18.6.
   4. Floor Drains: ASME A112.6.3.
   5. Grab Bars: ASTM F 446.
   6. Hose Coupling Threads: ASME B1.20.7.
   7. Off-Floor Fixture Supports: ASME A112.6.1M.
   8. Pipe Threads: ASME B1.20.1.
   9. Plastic Toilet Seats: ANSI Z124.5.
   10. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
   2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
   3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 2 of each type.
   4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
   5. Toilet Seats: Equal to 5% of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water. Comply with NSF 61, Annex G and NSF 372.

B. Lavatory Faucets LF-1: Sensor Operated, deck mounted metering solid-brass valve.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Sloan Optima ETF-600 or comparable product by one of the following:

      a. Delta
      b. American Standard

   2. Description: Lavatory faucet, three-hole fixture. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
      a. Body Material: Commercial, solid brass.
      b. Finish: Polished chrome plated.
      c. Maximum Flow Rate: 0.35 gpm (8.3L/min.), unless otherwise indicated.
      d. Mixing Valve: MVP Metering Adjustable Cycle Time Closure Cartridge.
      e. Centers: 4 inches (203 mm).
      f. Mounting: Deck, concealed.
      g. Inlet(s): NPS 1/2 (DN 15) male shank.

h. Spout Type: 4-9/16” Centered Integral Cast Brass Spout
i. Spout Outlet: Aerator.
j. Operation: Infrared Sensor, Electronic, 12 second duration
k. Drain: Grid.
l. Power: Foot mount transformer by Sloan model EL-208

2.2 SINK FAUCETS

A. Sink Faucets, SF-1:

1. Basis of Design Product: Subject to compliance with requirements, provide T&S Brass Model B-0666 faucet or a comparable product by one of the following:

   a. American Standard
   b. Delta

2. Description: Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Include hot-and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

   a. Body Material: Commercial, solid brass.
   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
   d. Mixing Valve: Two-lever handle.
   e. Backflow Protection Device for Hose Outlet: Required.
   f. Centers: 8 inches (203 mm).
   g. Mounting: Back/wall, exposed.
   h. Handle(s): Lever.
   i. Inlet(s): NPS 1/2 (DN 15) male shank.
   j. Spout Type: Rigid, solid brass with wall brace.
   k. Spout Outlet: Hose thread.
   l. Vacuum Breaker: Required.
   m. Operation: Compression, manual.
   n. Drain: Grid.
   o. Provide 3/8” offset with integral check.

B. Sink Faucets SF-2: Manual type, two-lever-handle mixing valve.

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard Monterrey faucet or comparable product by one of the following:

   a. Delta
   b. T&S Brass

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. Body Type: Widespread.
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome-plate.
7. Maximum Flow Rate: 2.0 gpm (8.3 L/min.).
8. Centers: 8 inches (203 mm).
9. Handle(s): 4” Wristblade.
10. Mounting Type: Deck, exposed.
11. Spout Type: 8” Tubular Brass Swivel
12. Swing Restrictor: Required for single compartment sinks.
13. Vacuum Breaker: Not required for hose outlet.

14. Spout Outlet: 0.5 GPM Aerator

C. Sink Faucets SF-3: Sensor operated.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Sloan Optima ETF-700 or comparable product by one of the following:

a. Delta
b. American Standard

2. Description: Lavatory faucet, three-hole fixture. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
a. Body Material: Commercial, solid brass.
b. Finish: Polished chrome plated.
c. Maximum Flow Rate: 0.5 gpm (8.3L/min.), unless otherwise indicated.
d. Mixing Valve: MVP Metering Adjustable Cycle Time Closure Cartridge.
e. Centers: Single Hole.
f. Mounting: Deck, concealed.
g. Inlet(s): NPS 1/2 (DN 15) male shank.
h. Spout Type: 8” Swing Rigid Gooseneck
i. Spout Outlet: Aerator.
j. Operation: Infrared Sensor, Electronic, 12 second duration
k. Drain: Grid.
l. Power: Foot mount transformer by Sloan model EL-208

2.3 SHOWER FAUCETS

A. Shower Faucets, SF-4 (P9):
1. Basis of Design Product: Subject to compliance with requirements, provide Chicago SH-PB1-11-034, or a comparable product by one of the following:
a. Delta Faucet Company.
b. Powers; a Watts Industries Co.
c. Symmons Industries.

2. Description: Single-handle thermostatic and pressure-balance valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.

a. Body Material: Solid brass.
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 1.5 gpm, unless otherwise indicated.
d. Diverter Valve: Pressure balancing, required..
e. Mounting: Concealed.
f. Backflow Protection Device for Hand-Held Shower: Required.
g. Operation: Noncompression, manual.
h. Antiscald Device: Integral with mixing valve.
i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
j. Supply Connections: NPS 1/2 (DN 15), sweat.
k. Shower Head Type: P-9: Overhead and Hand-held with integral slide bar mounted.
l. Shower Head Material: Metallic with chrome-plated finish.
m. Spray Pattern: Fixed.
n. Integral Volume Control: Required.
o. Shower-Arm Flow-Control Fitting: Not required
p. Temperature Indicator: Integral with faucet.

q. Water Sense Labeled.

2.4 FLUSHOMETERS

A. WATER CLOSET flushometer valve, Sensor Operated, Diaphragm Flushometer Valves (FV-1):

1. Manufacturers: Subject to compliance with requirements, provide products by Sloan Royal model 111 SFSM-1.28-HW or comparable product by one of the following:

   a. American Standard
   b. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
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. Consumption: 1.28 gal. per flush.
10. Minimum Inlet: NPS 1 (DN 25).
11. Minimum Outlet: NPS 1-1/4 (DN 32).
12. Power: Hard Wired

B. URINAL flushometer valve, Sensor Operated, Diaphram Flushometer Valves (FV-2):

1. Manufacturers: Subject to compliance with requirements, provide products by basis-of-design Sloan Royal model 186 SFSM-0.125-HW or comparable product by the following:

   a. American Standard
   b. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushmoeter-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated.
8. Style: Exposed.
9. Consumption: 0.125 gal. per flush.
10. Minimum Inlet: NPS ¾ (DN 20).
11. Minimum Outlet: NPS-1-1/4 (DN 32).
12. Power: Hard Wired

2.5 TOILET SEATS

A. Toilet Seats (TS-1):

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Bemis Manufacturing Company. Model 1655SSCT/
   b. Church Seats Model 9500SSCT
   c. Olsonite Seat Co.

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.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Engineered Brass Co.
   b. McGuire Manufacturing Co., Inc.
   c. TRUEBRO, Inc.

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.

2.7 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe: Wade Div.

B. Water Closet Supports:
1. Description: Combination carrier designed for accessible/standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space. Provide cast iron closet nipple/coupling.

C. Urinal Supports:

1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

2.8 INTERCEPTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Plumbing Products Group, model Z-1184.
   2. Josam.
   3. J. R. Smith.

B. Sediment Interceptors:

   1. Description: Manufactured unit with removable screens or strainer and removable cover; designed to trap and retain waste material.

      a. Material: carbon-steel body with acid-resistant lining and coating with stainless-steel removable screen bucket.
      b. Pipe Connections: NPS 2 (DN 50).
      c. Removable screens must be accessible from the top of the interceptor without the use of any tools.

2.9 WATER CLOSETS

A. Water Closets P1B: Adult ADA, Wall mounted, back outlet, top spud.

   1. Manufacturers: Subject to compliance with requirements, provide products by American Standard model Rapidway or comparable product by one of the following:

      a. Kohler Co.
      b. Sloan.

   2. Bowl:

      a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
      b. Material: Vitreous china.
      c. Type: Blowout.
      d. Style: Flushometer valve.
      e. Height: 17” handicapped complying with ICC/ANSI A117.1.
      f. Rim Contour: Elongated.
      g. Water Consumption: 1.28 gal. per flush.
      h. Spud Size and Location: NPS 1-1/2 (DN 40); top.
      i. Color: White.

   1. Flushometer Valve: (FV-1).
   2. Toilet Seat: 9500 SSC.
   3. Support: See “Fixture Supports” article.
   4. Water Sense Labeled.

B. Water Closets P1A: Adult Standard, Wall mounted, back outlet, top spud.

   1. Manufacturers: Subject to compliance with requirements, provide products by American Standard model Rapidway or comparable product by one of the following:

      a. Kohler Co.
      b. Sloan.

   2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Blowout.
d. Style: Flushometer valve.
e. Height: 15” to top of bowl.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. per flush.
h. Spud Size and Location: NPS 1-1/2 (DN 40); top.
i. Color: White or as selected by Architect.

3. Flushometer Valve: (FV-1).
4. Toilet Seat: 9500 SSC.
5. Support: See “Fixture Supports” article.
6. Water Sense Labeled

C. Water Closets P1A: Youth ADA, Wall mounted, back outlet, top spud.

1. Manufacturers: Subject to compliance with requirements, provide products by American Standard model Rapidway or comparable product by one of the following:

a. Kohler Co.
b. Sloan.

2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Blowout.
d. Style: Flushometer valve.
e. Height: 15” to top of bowl.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. per flush.
h. Spud Size and Location: NPS 1-1/2 (DN 40); top.
i. Color: White or as selected by Architect.

3. Flushometer Valve: (FV-1).
4. Toilet Seat: 9500 SSC.
5. Support: See “Fixture Supports” article.
6. Water Sense Labeled

2.10 URINALS

A. Urinals: Wall hung, back outlet: P2 standard; P2A accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by American Standard model Lynbrook or comparable product by the following:

a. Kohler Co.
b. Sloan.

2. Fixture:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Blowout.

d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
e. Water Consumption: 0.125 gal. per flush.
f. Spud Size and Location: NPS 1-1/4 (DN 20); top.
g. Outlet Size and Location: NPS 2 (DN 50); back.
h. Color: White.

3. Flushometer Valve: (FV-2).
4. Support: See “Fixture Supports” article.
5. Water Sense Labeled.

2.11 LAVATORIES

A. Lavatories, P3, P3A: Wheelchair, vitreous china, wall mounted for public restrooms:

1. Manufacturers: Subject to compliance with requirements, provide products by American Standard Lucerne or comparable products by the following:

a. Kohler Co.
b. Sloan.

2. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: P3A & P3B shall be Wheelchair (ADA) accessible.
c. Nominal Size: Rectangular 20 by 18 inches (686 by 559 mm).
d. Faucet-Hole Punching: One hole.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting: Concealed arm carrier.

3. Faucet: (LF-1).
4. Support: ASME A112.6.1M, Type II, concealed-arm lavatory carrier with rectangular, steel uprights.

2.12 MOP SINK

A. Mop Sink, P4:

1. Manufacturers: Basis of Design Product: Subject to Compliance with requirements, provide Crane Plumbing, LLC/Fiat Products, Fiat Model TSB-3003, or a comparable product of one of the following:

a. Acorn Engineering Company.
b. Stern-Williams Co., Inc.
c. Florestone Products Co., Inc.

2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard.

a. Shape: Rectangular.
b. Size: 36 by 24 inches (915mm by 610 mm).
c. Height: 12 inches (305 mm) with 6” dropped front.
d. Tiling Flange: On all sides.
e. Rim Guard: Stainless steel cap on all top surfaces.

f. Color: Black and white marble chips.
g. Faucet: Wall-Mounted Chicago Faucet 540-LD897SWXFCP.
h. Drain: Grid with NPS 3 (DN 80) outlet.
i. Wall Guards: Heavy gauge stainless steel on all walls.
j. Mop Hangers: Provide four (4) hangers.
k. Faucet: SF-1
    1) Number required: One
    2) Mounting: Wall

2.13 SINKS

A. Classroom Sink (2-Compartment) P5:
1. Basis of Design Product: Subject to compliance with requirements, provide Just UA-ADA-1832-A or a comparable product by one of the following:
    a. Advance Tabco.
    b. Elkay Manufacturing Co.

2. Fixture:
    a. Standard: ASME A112.19.3/CSA B45.4.
    b. Type: Undermount.
    c. Number of Compartments: Two.
    d. Overall Dimensions: 32” x 18”x 5-1/2”.
    e. Meal Thickness: 18 gauge.
    f. Compartment (Each):
        1) Dimensions: 14” x 16” x 5-1/2”
        2) Drain: Just J-35, Stainless Steel Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain.
        3) Drain Location: Near back of compartment.
    g. Faucet Hole Punching: 3 hole, back.
3. Faucet: SF-2
    a. Number Required: One.
    b. Mounting: ON ledge.
4. Supply Fittings:
    a. Standard: ASME A112.18.1/CSA B125.1.
    b. Supplies: Chrome-plated brass threaded stop with inlet connection matching water-supply piping type and size.
        1) Operation: Loose key.
        2) Risers: NSP 1/2 (DN 15), chrome-plated, soft-copper flexible tube.
5. Waste Fittings:
    a. Standard: ASME A112.18.2/CSA B125.2.
    b. Trap(s):
        1) Size: NPS 1-1/2 (DN 40).
        2) Materials: Chrome-plated two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm thick brass tube to wall and chrome-plated brass or steel wall flange.
        3) Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-(0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.
    c. Continuous Waste:
        1) Size: NPS 1-1/2 (DN 40).
        2) Material: Chrome-plated, 0.032-inch (0.83 mm) thick brass tube

B. Classroom Sink (1-Compartment) P5A:
1. Basis of Design Product: Subject to compliance with requirements, provide Just US-ADA-1824-A or a comparable product by one of the following:
    a. Advance Tabco.

b. Elkay Manufacturing Co.

2. Fixture:
   a. Standard: ASME A112.19.3/CSA B45.4.
   b. Type: Undermount.
   c. Number of Compartments: One.
   d. Overall Dimensions: 24” x 18”x 5-1/2”.
   e. Meal Thickness: 18 gauge.
   f. Compartment:
      1) Dimensions: 22” x 16” x 5-1/2”
      2) Drain: Just J-35, Stainless Steel Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain.
      3) Drain Location: Near back of compartment.
   g. Faucet Hole Punching: 3 hole, back.
3. Faucet: SF-2
   a. Number Required: One.
   b. Mounting: ON ledge.
4. Supply Fittings:
   a. Standard: ASME A112.18.1/CSA B125.1.
   b. Supplies: Chrome-plated brass threaded stop with inlet connection matching water-supply piping type and size.
      1) Operation: Loose key.
      2) Risers: NSP 1/2 (DN 15), chrome-plated, soft-copper flexible tube.
5. Waste Fittings:
   a. Standard: ASME A112.18.2/CSA B125.2.
   b. Trap(s):
      1) Size: NPS 1-1/2 (DN 40).
      2) Materials: Chrome-plated two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm thick brass tube to wall and chrome-plated brass or steel wall flange.
      3) Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-(0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.
   c. Continuous Waste:
      1) Size: NPS 1-1/2 (DN 40).
      2) Material: Chrome-plated, 0.032-inch (0.83 mm) thick brass tube

C. Art Sink (1-Compartment) P5B:
1. Basis of Design Product: Subject to compliance with requirements, provide Just US-ADA-1824-A or a comparable product by one of the following:
   a. Advance Tabco.
   b. Elkay Manufacturing Co.

2. Fixture:
   a. Standard: ASME A112.19.3/CSA B45.4.
   b. Type: Undermount.
   c. Number of Compartments: One.
   d. Overall Dimensions: 24” x 18”x 5-1/2”.
   e. Meal Thickness: 18 gauge.
   f. Compartment:
      1) Dimensions: 22” x 16” x 5-1/2”
      2) Drain: Just J-35, Stainless Steel Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain.
      3) Drain Location: Near back of compartment.
   g. Faucet Hole Punching: Single hole, back.
3. Faucet: SF-3
   a. Number Required: One.

b. Mounting: ON ledge.

4. Supply Fittings:
   a. Standard: ASME A112.18.1/CSA B125.1.
   b. Supplies: Chrome-plated brass threaded stop with inlet connection matching water-supply piping type and size.
      1) Operation: Loose key.
      2) Risers: NSP 1/2 (DN 15), chrome-plated, soft-copper flexible tube.
5. Waste Fittings:
   a. Standard: ASME A112.18.2/CSA B125.2.
   b. Trap(s):
      1) Size: NPS 1-1/2 (DN 40).
      2) Material: Chrome-plated to trap; Zurn Model Z-1180 top access solids trap with removable stainless steel bucket and chrome-plated brass or steel wall flange.
   c. Continuous Waste:
      1) Size: NPS 1-1/2 (DN 40).
      2) Material: Chrome-plated, 0.032-inch (0.83 mm) thick brass tube

D. Art Cleanup Sink (1-Compartment) P5C:
1. Basis of Design Product: Subject to compliance with requirements, provide Just USXDN-1830-A or a comparable product by one of the following:
   a. Advance Tabco.
   b. Elkay Manufacturing Co.

2. Fixture:
   a. Standard: ASME A112.19.3/CSA B45.4.
   b. Type: Undermount.
   c. Number of Compartments: One.
   d. Overall Dimensions: 30” x 18”x 12”.
   e. Meal Thickness: 18 gauge.
   f. Compartment:
      1) Dimensions: 28” x 18” x 12”
      2) Drain: Just J-35, Stainless Steel Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain.
      3) Drain Location: Near back of compartment.
   g. Faucet Hole Punching: 3 hole, back.
3. Faucet: SF-2
   a. Number Required: One.
   b. Mounting: ON ledge.
4. Supply Fittings:
   a. Standard: ASME A112.18.1/CSA B125.1.
   b. Supplies: Chrome-plated brass threaded stop with inlet connection matching water-supply piping type and size.
      1) Operation: Loose key.
      2) Risers: NSP 1/2 (DN 15), chrome-plated, soft-copper flexible tube.
5. Waste Fittings:
   a. Standard: ASME A112.18.2/CSA B125.2.
   b. Trap(s):
      1) Size: NPS 1-1/2 (DN 40).
      2) Material: Chrome-plated to trap; Zurn Model Z-1180 top access solids trap with removable stainless steel bucket and chrome-plated brass or steel wall flange.
   c. Continuous Waste:
      1) Size: NPS 1-1/2 (DN 40).
      2) Material: Chrome-plated, 0.032-inch (0.83 mm) thick brass tube

E. Cleanup Sink (1-Compartment) P5D:
1. Basis of Design Product: Subject to compliance with requirements, provide Just USXDN-1830-A or a comparable product by one of the following:
   a. Advance Tabco.
   b. Elkay Manufacturing Co.

2. Fixture:
   a. Standard: ASME A112.19.3/CSA B45.4.
   b. Type: Undermount.
   c. Number of Compartments: One.
   d. Overall Dimensions: 30” x 18”x 12”.
   e. Meal Thickness: 18 gauge.
   f. Compartment:
      1) Dimensions: 28” x 18” x 12”
      2) Drain: Just J-35, Stainless Steel Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain.
      3) Drain Location: Near back of compartment.
   g. Faucet Hole Punching: 3 hole, back.
3. Faucet: SF-2
   a. Number Required: One.
   b. Mounting: ON ledge.
4. Supply Fittings:
   a. Standard: ASME A112.18.1/CSA B125.1.
   b. Supplies: Chrome-plated brass threaded stop with inlet connection matching water-supply piping type and size.
      1) Operation: Loose key.
      2) Risers: NSP 1/2 (DN 15), chrome-plated, soft-copper flexible tube.
5. Waste Fittings:
   a. Standard: ASME A112.18.2/CSA B125.2.
   b. Trap(s):
      1) Size: NPS 1-1/2 (DN 40).
      2) Materials: Chrome-plated two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm thick brass tube to wall and chrome-plated brass or steel wall flange.
      3) Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-(0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.
   c. Continuous Waste:
      1) Size: NPS 1-1/2 (DN 40).
      2) Material: Chrome-plated, 0.032-inch (0.83 mm) thick brass tube

F. Utility Sink P-11:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Just Manufacturing Single Compartment Scullery Sink Model NSFB-124-12/12, or a comparable product by one of the following:
   a. Elkay.
2. Description: One-compartment, counter-mounting, self rimming, stainless-steel commercial sink fully undercoated to damper sound and prevent condensation.
   a. Overall Dimensions: 27”W x 27”D x 48”H
   b. Metal Thickness: 14 gauge, Type 304 (18-8) stainless steel.
   c. Compartment:
      1) Dimensions: 24” x 24” x 12” deep.
         a) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece.
         b) Location: Center of compartment.
   d. Faucet: SF-1
      1) Number required: One
      2) Mounting: Wall

e. Supplies: NPS 1/2 (DN 15) chrome-plated copper with loose-key, angle service stops. Chicago Model 1006-ABCP with supply risers.
f. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Material: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P trap with clean-out; 0.045-inch (1.1-mm) thick tubular brass waste to wall; and wall escutcheons.

2.14 SUPPLY BOXES

A. Cold Water Supply Box – P7:
1. Manufacturers:
a. I.P.S. Corp, Model M1B1.
b. Oatey.
c. Guy Grey.
2. Description: Recessed 304 Steel Box.
a. 8”L x 8”W x 4”D clear interior dimensions.
b. Vandal Resistant lock with Torx Screwdriver.
c. Concealed pivot pins hinge.

B. Clothes Washer Box – P8:
1. Manufacturers:
a. Guy Grey Model BB200TS.
b. Oatey.
c. I.P.S. Corp.
2. Description: Recessed steel box, epoxy finish
a. Two-inch drain.
b. One-half inch CW and HW angle valves with hose end thread.

C. Valve Box:
1. Manufacturers:
a. MIFAB Model # MI-VBSS080806-VP or as approved equal.
2. Description: Recessed Steel Box, epoxy finish.
a. One-quarter turn chrome valves.

2.15 DISH WASHER AIR-GAP FITTINGS

A. Dishwasher Air-Gap Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. B&K Industries, Inc.
b. Brass Craft Mfg. Co.; a Subsidiary of Masco Corporation.
c. Brasstech Inc.; Newport Brass Div.
d. Dearborn Brass; A Div. of Moen, Inc.
e. Geberit Manufacturing, Inc.
f. JB Products, a Federal Process Corporation Company.
g. Sioux Chief Manufacturing Company, Inc.
h. Watts brass & Tubular; a Division of Watts Regulator Co.
2. Description: fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body, chrome-plated brass cover; and capacity of at least 5 gpm (0.32 L/s); and inlet pressure of at least 5 psig (35 kPa) at a temperature of at least 140 deg F (60 deg C). Include 5/8-inch – (16-mm) ID inlet and 7/8-inch (22-mm) ID outlet hose connections.

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 plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install counter-mounting fixtures in and attached to casework.

G. Install fixtures level and plumb according to roughing-in drawings.

H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

I. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

J. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

K. Install flushometer valves for accessible water closets with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

L. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

M. Install toilet seats on water closets.

N. Install trap-seal liquid in dry urinals.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install shower flow-control fittings with specified maximum flow rates in shower arms.

S. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

T. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

U. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

V. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

W. All valves on supplies shall have threaded connections. Compression style valves are prohibited.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers and controls. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

E. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

- END OF SECTION 22 40 00 -

SECTION 22 45 00
EMERGENCY PLUMBING FIXTURES

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. Eyewash equipment.
2. Water-tempering equipment.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures to include in 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. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

D. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

PART 2 PRODUCTS

2.1 EYEWASH EQUIPMENT

A. Sink, Swing-Down type, Plumbed Eyewash Unit P8A:

1. Basis of Design Product: Subject to compliance with requirements, provide Guardian Equipment Co. Model: G1848 or comparable product by one of the following:

   a. Guardian Equipment Co.
   b. Acorn Safety; a division of Acorn Engineering Company.
   c. Haws Corporation.

2. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.

3. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass with flow regulator and stay-open control valve.

4. Control-Valve Actuator: Swing down activation.

5. Control Spray-Head Assembly: Two spray heads with offset piping.

6. Mounting: Wall.

2.2 WATER-TEMPERING EQUIPMENT

A. Hot and Cold-Water, Water-Tempering Equipment, (WTD-2)
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Powers Model ES 150 or comparable product by one of the following:

      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Armstrong International, Inc.
      c. Bradley Corporation.
      d. Encon Safety Products.
      e. Guardian Equipment Co.
      f. Haws Corporation.
      g. Lawler Manufacturing Co., Inc.
      h. Leonard Valve Company.

2. Description: Factory-fabricated equipment with thermostatic mixing valve.

   a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
   b. Supply Connections: For hot and cold water.
   c. ASSE 1071 compliant.

B. Hot- and Cold-Water, Water-Tempering Equipment, (WTD-3)
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Powers Model ETV 200 or comparable product by one of the following:

      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Armstrong International, Inc.
      c. Bradley Corporation.
      d. Encon Safety Products.
      e. Guardian Equipment Co.
      f. Haws Corporation.
      g. Lawler Manufacturing Co., Inc.
      h. Leonard Valve Company.

   2. Description: Factory-fabricated equipment with thermostatic mixing valve.

      a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
      b. Supply Connections: For hot and cold water.
      c. ASSE 1071 compliant.

2.3 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

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

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Division 22 Section "Meters and Gages for Plumbing Piping."

3.3 CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

C. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

- END OF SECTION 22 45 00 -

SECTION 22 47 00
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. This Section includes the following water coolers and related components:
   1. Pressure water coolers.
   2. Fixture supports.

1.3 DEFINITIONS

A. Accessible Drinking Fountain or Water Cooler: Fixture that can be approached and used by people with disabilities.

B. Cast Polymer: Dense, cast-filled-polymer plastic.

C. Fitting: Device that controls flow of water into or out of fixture.

D. Fixture: Water cooler unless one is specifically indicated.

E. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

F. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

1.4 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

D. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.

E. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Water Coolers, P-6 (Accessible with Bottle Filler):

1. Manufacturers: Basis of Design Product: Subject to compliance with requirements, provide Halsey Taylor, HTHB-HAC8BLSS-WF or a comparable product by one of the following:
   a. Haws Corporation.
   b. Oasis Corporation.

2. Description: Accessible, Bi-Level, ARI 1010, Type PB, pressure with bubbler and bottle filler, Style W, wall-mounting water cooler for child-mounting height.

   a. Cabinet: Bi-level with two attached cabinets made from all stainless steel.
   b. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
   c. Control: Push bar.
   d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
   e. Drain(s): Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.1.
   f. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, R-134A refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

      1) Capacity: 8 gph (0.0084 L/s) of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
      2) Electrical Characteristics: 120-V ac; single phase; 60 Hz.

   g. Support: Type I, water cooler carrier for each. J. R. Smith Model 0800. Refer to "Fixture Supports" Article.

2.2 FIXTURE SUPPORTS

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

1. Josam Co.
2. MIFAB Manufacturing, Inc.
3. Smith, Jay R. Mfg. Co.
4. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
5. Wade.
6. Zurn Plumbing Products Group.

B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
1. Type I: Hanger type carrier with two vertical uprights.
2. Supports for accessible fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

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

3.2 APPLICATIONS

A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.

B. Use mounting frames for recessed water coolers, unless otherwise indicated.

C. Set freestanding and pedestal drinking fountains on floor.

D. Set remote water coolers on floor, unless otherwise indicated.

E. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.

B. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.

C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

E. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

F. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

G. Install mounting frames affixed to building construction and attach recessed, wall-mounted water coolers to mounting frames.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
   1. Remove and replace malfunctioning units and retest as specified above.
   2. Report test results in writing.

3.6 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, 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.

3.8 WARRANTY

A. Provide two (2) year warranty for water coolers and a five (5) year parts, labor and refrigerant warranty for the refrigeration system.

B. Warranty shall start at substantial completion.

- END OF SECTION 224700 -

SECTION 22 63 23
FACILITY NATURAL-GAS 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. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Service meters.
7. Concrete bases.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
2. Service Regulators: 100 psig (690 kPa) minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 5 psig (34.5 kPa) –coordinate with PECO.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa).

C. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

1.5 SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

B. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

D. Welding certificates.

E. Field quality-control reports.

F. Operation and Maintenance Data: For motorized gas valves and pressure regulator to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Steel Support 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.

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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Architect and Owner no fewer than seven days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Architect's and Owner's written permission.
3. Disruptions during normal school hours is not permitted.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

   a. Material Group: 1.1.
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
   e. Bolts and Nuts: ASME B18.2.1, galvanized
   f. steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

a. 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) Dresser Piping Specialties; Division of Dresser, Inc.
2) Smith-Blair, Inc.

b. Steel flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. Stainless-steel bolts, washers, and nuts.
e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm).

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shut-off when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

B. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig (862 kPa).
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. 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. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.
    f. Maxitrol.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

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. Lee Brass Company.
    b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa).
7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

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. McDonald, A. Y. Mfg. Co.
    b. Mueller Co.; Gas Products Div.
    c. Xomox Corporation; a Crane company.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.

5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Valve Boxes:

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

2.5 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

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

   a. ASCO Power Technologies, LP; Division of Emerson.
   b. Dungs, Karl, Inc.
   c. Eaton Corporation; Controls Div.
   d. Eclipse Combustion, Inc.
   e. Honeywell International Inc.
   f. Johnson Controls.

2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. Normally closed.
6. Visual position indicator.
7. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

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

   a. ASCO Power Technologies, LP; Division of Emerson.
   b. Dungs, Karl, Inc.
   c. Eclipse Combustion, Inc.
   d. Goyen Valve Corp.; Tyco Environmental Systems.
   e. Magnatrol Valve Corporation.
   f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
   g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Visual position indicator.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

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

   a. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   b. Invensys.
   c. Equimeter.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig (690 kPa).

C. Line Pressure Regulators: Comply with ANSI Z21.80.

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

   a. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   b. Invensys.
   c. Maxitrol Company.
   d. Equimeter.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig (13.8 kPa).

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

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

   a. Eclipse.
   b. Eaton Corporation; Controls Div.
   c. Harper Wyman Co.
   d. Maxitrol Company.
   e. SCP, Inc.
   f. Fischer.

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig (13.8 kPa).

2.7 DIELECTRIC FITTINGS

A. Dielectric Flanges:

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

   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   d. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.

5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric-Flange Kits:

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

   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric unions and couplings are not permitted.

2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54, the International Fuel Gas Code and utility provider for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches (900 mm**)** below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

   1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
   3. Replace pipe having damaged PE coating with new pipe.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap and relief vent pipe and fittings shall be galvanized.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gauge upstream and downstream from each line regulator. Pressure gauges are specified in Division 23 Section "Meters and Gauges for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

Z. Provide a manual gas shut-off valve(s) for gas piping serving individual appliances and kitchen equipment.

AA. Provide a gas pressure regulator to reduce pressure to gas piping serving individual appliances and kitchen equipment.

BB. Coordinate all gas piping requirements, type of outlets, locations, and quantities of outlets with the kitchen/food service Contractor. Refer to the kitchen/food service Specifications and Architectural Drawings for additional information regarding gas piping systems services, outlets, and requirements serving the kitchen.

CC. Appliances include but not limited to makeup air unit, boilers, water heaters, emergency generator and all cooking equipment.

DD. Install all valving and piping to the emergency generator in accordance with the authorities having jurisdiction, IPC, NFPA and the manufacturers recommendations.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
c. Topcoat: Exterior alkyd enamel (semigloss).
d. Color: Yellow.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.

a. Prime Coat: Quick-drying alkyd metal primer.
b. Intermediate Coat: Interior latex matching topcoat.
c. Topcoat: Interior latex (flat).
d. Color: Yellow.

2. Alkyd System: MPI INT 5.1E.

a. Prime Coat: Quick-drying alkyd metal primer.
b. Intermediate Coat: Interior alkyd matching topcoat.
c. Topcoat: Interior alkyd (flat).
d. Color: Yellow.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas and gas vent piping shall be the following:

1. Hot Dipped Galvanized Schedule 40 Steel pipe with malleable-iron fittings and threaded joints.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:
1. Schedule 40 Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Schedule 40 Steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40 Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be one of the following:
1. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:
1. Schedule 40 Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Schedule 40 Steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40 Steel pipe with steel welding fittings and welded joints.

C. Underground, below building, piping shall be the following:

1. Schedule 40 Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:

1. Two-piece, full -port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

E. Valves in branch piping for single appliance shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 226323

SECTION 23 05 00
COMMON WORK RESULTS 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. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, ductwork, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with "Submittals" specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

G. The project will be fully commissioned by an independent commissioning agency. Include in the bid to coordinate all commissioning activities and requirements with the Commissioning Authority

H. Indicate as separate line items in the Schedule of Values the following:
   1. O & M Manuals.
   2. Record Drawings/As-Builts.
   3. ATC Shop Drawings

I. Coordinate the work under Division 23 with work of all other construction trades.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

   1. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PE: Polyethylene plastic.
   3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

   1. EPDM: Ethylene-propylene-diene terpolymer rubber.
   2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. Welding certificates.

C. LEED Submittals: Comply with Section 018113

   1. EQ Credit 2: Low emitting materials
      a. For interior we applied welding solvent, cement adhesives, sealants, paints and coatings: Documentation indicating compliance with California Department of

Public Health (CDPH) Standard Method V1.1 – 2010 and VOC content in g/l. Include volume of material applied per product.

2. EQ Credit 3: Construction Indoor Air Quality Management
   a. For filter media installed during construction and prior to occupancy documentation indicating MERV rating class of filter.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified at no cost to the owner. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 23.

1.8 PERMITS AND FEES:

A. The Contractor shall obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the General Requirements of the specifications.

1.9 EXAMINATION OF SITE:

A. Examine the site, determine all conditions and circumstances under which the work must be performed, and make all necessary allowances for same. No additional cost to the Owner will be permitted for Contractor's failure to do so.

1.10 CONTRACTOR QUALIFICATION:

A. Any Contractor or subcontractor performing work under Division 23 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence if requested.
   1. A list of not less than five comparable projects that the Contractor completed.
   2. Letter of reference form not less than three registered professional engineers, general contractors or building owners.
   3. Local and/or State License, where required.
   4. Membership in trade or professional organizations where required.

B. A Contactor is any individual, partnership, or corporation, performing work by Contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

D. VRF/VRV installing contractor shall be factory certified and shall have a minimum of five (5) years and ten (10) similar projects (capacity, quantity and type of units, etc.) using the proposed manufacturer products. Submit certifications for all installers.

1.11 MATERIALS AND EQUIPMENT:

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. This Contractor shall be responsible for connecting all utilities as shown on the Drawings to equipment identified as "Under Another Division".

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or it's equal of manufacturer indicated in this specification. Alternate Manufacturers (other than first named or indicated as the basis of design) shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of alternate manufacturers for review.

C. The suitability of named item only has been verified. Where more than one Manufacturer is named, only the first named Manufacturer has been verified as suitable. Manufacturers and items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application.

D. Substitution (manufacturer or items not listed) will not be permitted for specified items of material or equipment.

E. The Contractor shall only submit those manufacturers indicated in the specification or included by Addendum. Proposed manufacturers not specified will not be considered unless the specific item indicates "or as approved equal" or “but are not limited to”. Submit all data necessary to determine suitability of alternative manufacturers’ items for approval. Failure to do so will result in a “Revise and Resubmit” response.

F. Refer to the General Conditions of this specification for additional information, including substitution request. Substitutions are for materials or manufacturers not listed in this specification. For each substitution proposed by the Contractor, the Contractor clearly identifies all differences (i.e., paragraph-by-paragraph, performance differences, physical differences, etc.) from the specified item, changes in Contract cost, benefits to the Owner and a brief description why the substitution is being proposed.

G. Where only one manufacturer is listed, provide that manufacturer-sole source.

H. For proposed products other than first named, all differences in cost shall be at no expense to the owner. The contractor shall include in their bid all cost associated with the proposed alternate manufacturer including cost for other trades (steel, electrical etc.). The coordination of all trades and burden of proof that the proposed product other than the basis of design is suitable, fits the space, allows for similar clearances and access for servicing and maintenance and meets or exceeds the performance of the basis of design equipment/system.

1.12 FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA or ASTM Standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.13 REFERENCED STANDARDS, CODES AND SPECIFICATIONS:

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

AABC - Associated Air Balance Council
ABMA - American Boiler Manufacturers Association
ACCA - Air Conditioning Contractors of America
ACGIH - American Conference of Governmental Industrial Hygienist
AIHA - American Industrial Hygiene Association
ASA - Acoustical Society of America
ADC - Air Diffusion Council
AGA - American Gas Association
AMCA - Air Movement and Control Association
ANSI - American National Standards Institute
ARI - Air Conditioning and Refrigeration Institute
ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME - American Society of Mechanical Engineers
ASTM - American Society for Testing and Materials
AWWA - American Water Works Association
CABO - Council of American Building Officials
CAGI - Compressed Air and Gas Institute
CS - Commercial Standard
CSA - Canadian Standards Association

CISPI - Cast Iron Soil Pipe Institute
IBC - International Building Code, Latest Edition.
IBR - Institute of Boiler and Radiator Manufacturers
IEEE - Institute of Electrical and Electronics Engineers
IMC - International Mechanical Code, Latest Edition
MSSP - Manufacturers Standards Society of the Valve and Fittings Industry
NEC - National Electrical Code
NEMA - National Electrical Manufacturers Association
NFPA - National Fire Protection Association
NSPC - National Standard Plumbing Code, Latest Edition
SMACNA - Sheet Metal and Air Conditioning Contractors National Association
TEMA - Tubular Exchanger Manufacturers Association
UL - Underwriters' Laboratories

B. All mechanical equipment and materials shall comply with the codes and standards listed in the latest ASHRAE Handbook

1.14 SUBMITTALS REVIEW AND ACCEPTANCE:

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Engineer to be in the best interest of the Owner.

B. Within 30 calendar days after award of contract, submit Material and Equipment List for approval. List all materials and equipment, indicating manufacturer, type, class, model, curves, and other general identifying information.

C. After acceptance of Material and Equipment List, submit complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, sound data, performance certifications, wiring diagrams, specific electrical/wiring requirements and connections including control and interlock wiring, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project or submittal shall be rejected.

D. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and all electrical requirements for equipment submitted. Submit the Electrical Connection information specified in Division 26 for each piece of equipment requiring electrical connections. As a minimum, the Electrical Connection Information shall include horsepower or kVA, voltage and phase, power factor, capacitor, motor starter, disconnect and controls. Indicate which Division is providing the devices. Each piece of equipment and its associated components (fuses, relays, etc.) shall be clearly identified. Failure to include this schedule in the submittal will result in the submittal being returned to the Contractor for resubmission due to incompleteness of the submittal. If the Contractor submits equipment other than that used for the basis of design, and if the electrical connection requirements are different, the Contractor shall be responsible for any associated increase in cost (e.g., wiring, conduits, starters, disconnects, etc.). Maintain and submit a summary of all electrical connection schedules of approved equipment. All mechanical equipment must be approved before electrical distribution equipment shall be approved for fabrication (i.e., MC, switchboard, emergency generator, distribution panels, etc.) Contractor shall be responsible for correctness of all submittals.

E. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

F. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs where applicable. Clearly indicate exact type, model number, manufacturer, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For all items clearly list on the first page of the Submittal all differences between the specified product and the submitted product. Additionally, for items other than first-named or indicated as the Basis of Design, clearly list on the first page of the submittal all differences between the specified item and the proposed item. This includes a paragraph-by-paragraph comparison from the Specification, performance differences from that scheduled and/or indicated on the Drawings, including power connection requirements, sound, etc., and physical differences (size, weight, etc.) based on published data (i.e., including Web sites.) The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements if differences have not been clearly indicated in the submittal.

G. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable.

H. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.

I. The Contractor is responsible for notifying the Owner and of any changes, substitutions and/or alternative materials/manufacturers that are proposed as equal after the project has bid or submittal has been received.

J. The Contractor shall be responsible for all cost differences when utilizing alternative manufacturers. Alternative manufacturers have been indicated in the specification based on quality of their product. Products are manufactured differently and may have different electrical requirements, connections, etc. The Contractor shall coordinate these differences during the bid phase with all other trade contractors and include all premiums in their bid for these differences when proposing alterative manufacturers. If alternative manufacturers are submitted and acceptable for use on the project by meeting all the specification requirements, then all cost (including all trades) shall be included in their bid (i.e. no additional cost to the Owner.)

1.15 SHOP DRAWINGS:

A. Prepare and submit shop drawings within ten calendar days after award of contract for all specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings as listed below, in addition to provisions of paragraph 1 above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number.

Items and Systems Included But Not Limited To:

Access Doors.
Air Curtain
Air Distribution Systems.
Air Handling Units (all types) and Air Cooled Condensing Units
Air Terminal Devices (all types)
Automatic Temperature Control & Energy Management System & Equipment.
Baseboard Radiation
Cabinet Unit Heaters.
Capacitors.

Combination Fire/Smoke Dampers.
Ductless Split A/C Unit.
Fans.
Fire Dampers.
Fire Stopping - Methods and Materials
Flues and combustion air intake vents
Grilles, Registers, Diffusers, and Fire Dampers.
Gravity Roof Vents.
Identification System.
Kitchen Hood Make-Up Air Unit.
Pipe Guides, Anchors, Hangers, and Supports.
Pipe Materials and Fittings.
Pipe Sleeves Including Sealants.
Pool Dehumidification Unit
Roof Curb Assemblies
Thermal Insulation Materials.
Unit Heaters (all types)
Variable Speed Drives.
Vibration Isolation.
Variable Refrigerant Volume/Flow (VRV/VRF) System.

C. Contractor, additionally, shall submit for approval any other shop drawings as required by the Architect or Owner. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Architect/Owner.

1.16 SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of work under the Contract, including that of subcontractors.

B. Coordinate rough-in of work and installation of sleeves, anchors, and supports for piping, ductwork, and other work performed under Division 23.

C. Coordinate electrical work required under Division 23 with that under Division 26. Coordinate work under Division 23 with work under other Divisions.

D. Coordinate the work under Division 23 with the work of all other construction trades.

E. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

G. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 23.

1.17 CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 23. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore

disturbed work to match and blend with existing, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval.

1.18 PENETRATION OF WATERPROOF CONSTRUCTION:

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where vents or other pipes penetrate roofs, flash pipe with All American Metal, Inc., or approved equal, roof flashing assemblies, with 4-pound lead, 6-inch skirt and caulked counterflashing sleeve with cap.

C. Furnish and install vent assemblies and duct sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions, The National Roofing Contractors Association, SMACNA and as required by other divisions of this specification. The Contractor shall be responsible for sleeve sizes and locations.

1.19 VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors, and/or foundations required to prevent transmission of vibration from equipment, piping, or ductwork to building structure. See Section 230548, VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

1.20 ACCESSIBILITY

A. All equipment shall be installed in such a way that all components requiring access (such as panels, disconnect switches, circuit breakers, starters, and accessories) are so located and installed that they may be serviced, reset, replaced, recalibrated, etc., by service technicians in accordance with the Manufacturer’s recommendations. If any equipment or components are located in such a position that this Contractor cannot comply with the above, the Contractor shall notify the engineer in writing before equipment is installed.

1.21 CONCRETE AND MASONRY WORK:

A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 23. Perform work in accordance with requirements of other applicable Divisions of these specifications. Coordinate size and location of all sleeves, concrete inserts, etc., with other Divisions, equipment connections, and approved casework Shop Drawings.

B. Concrete shall test not less than 5,000 psi compressive strength after 28 days.

C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

D. Provide 4” thick Pearlite Concrete, 30-35 PCF, in all rooftop AHU curbs.

1.22 DRIVE GUARDS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.

B. Fabricate guards of heavy gauge steel, rigidly brace, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet O.S.H.A. and Authorities Having Jurisdiction requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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 manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, galvanized steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

J. Interior wet applied welding solvents and adhesives: Comply with low emitting requirements in Division 01, Section “Sustainable Design Requirements – LEED”

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Available Manufacturers or equal:

a. Eslon Thermoplastics.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers or equal:

a. Thompson Plastics, Inc.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Manufacturers or equal:

a. NIBCO INC.
b. NIBCO, Inc.; Chemtrol Div.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

E. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Manufacturers:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.
e. Linkseal.

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless Steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

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

1. Underdeck Clamp: Clamping ring with set screws.

C. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

C. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. 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 with spring clips.
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.

M. Sleeves are required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

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

a. Exception: Extend sleeves installed in floors 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are two pipe sizes larger than pipe or pipe insulation.
a. Galvanized Steel Pipe Sleeves: For pipes penetrating floors, walls and roofs except where noted through membrane waterproofing.
b. Galvanized steel sheet sleeves: For pipes penetrating gypsum-board partitions.
c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing. Seal space outside of sleeve fittings with grout.
d. Provide galvanized steel sheet sleeves for interior stud partitions.

e. Provide galvanized steel wall sleeves with sleeve seal system for walls below grade and concrete slabs on grade. Select sleeve size to allow one-inch annular clear space between piping and sleeve for installing sleeve seal system. Select type, size and number of sealing elements required for piping material and size for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve 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 water-tight seal.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size two pipe sizes larger than pipe and sleeve for installing mechanical sleeve seals.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using 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.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Joint Firestopping" for materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.
5. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric nipples and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Division 09 Sections "Painting and Coatings," unless otherwise indicated.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. For interior components, paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, vibration isolators, etc., shall be galvanized or stainless steel. All exterior fastening components such as rods, nuts, bolts, washers, etc., shall be stainless steel.

D. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

E. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

F. Protect all finishes and restore any finishes damaged as a result of work under Division 23 to their original condition.

G. The preceding requirements apply to all work, whether exposed or concealed.

H. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

I. All exposed ductwork, piping, equipment, etc. shall be painted. All finishes shall have a paint grip finish, including galvanized ductwork which shall be Gavanneal type. Colors shall be selected by the Architect and conform to ANSI Standards.

J. Submit color of factory-finished equipment for approval prior to ordering. Color of finishes shall be as selected by Architect. All exposed cabinets for equipment (e.g., fin tube radiation, fan coil units, cabinet unit heaters, terminal heating devices, etc.) in finished areas shall be provided with custom colors as selected by the Architect.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

7. Use 5000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section “Cast-in-Place Concrete."
8. Housekeeping pads for air handling units shall be a minimum of 6-inches thick. All other equipment pads shall be a minimum of 4-inches thick.
9. Provide wire-mesh or re-bar reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.9 SUPPORTS, HANGERS, AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For uninsulated copper piping/tubing provide copper hanger with wool or felt insert to prevent contact of dissimilar metals. All exterior hangers shall be constructed of galvanized steel or stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

C. No support or hanger shall attach to the metal roof deck.

D. Hangers shall attach at the panel point of the top chord of joist.

3.10 PROVISIONS FOR ACCESS:

A. The Contractor shall provide access panels and doors for all concealed equipment, valves, strainers, manual, gravity and automatic dampers, filters, controls, control devices, cleanouts, fire dampers, smoke dampers, combination fire and smoke dampers, damper operators, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured steel door assemblies consisting of hinged door, cylinder with key locks (keyed alike), and frame designed for the particular wall or ceiling construction. Style M access door shall have stainless steel finish. All others shall have paintable finish. Properly locate each door. Review all locations with the Engineer and Architect in the field before installation. Door size shall be a minimum of 24" x 24". Provide UL approved and "B" labeled 12-Hour Access doors where installed in fire-rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Air Balance, Inc., Cesco, Karp Associates, Kees, or approved equal.

1. Acoustical: Style AT
2. Hard Finish Plaster: Style K
3. Dry Wall: Style DW
4. Masonry Style M

C. Where access is by means of lift-out ceiling tiles or panels, mark each ceiling grid using small color-coded or numbered tabs. Provide a chart or index for identification. Charts shall be similar to valve charts specified hereinafter. Screw markers on ceiling grid.

D. Access panels, doors, etc., described herein shall be furnished under the section of specifications providing the particular service to be turned over to the pertinent trade for installation. Coordinate installation with installing Contractor.

E. Per the owner’s standard provide white micarta nameplates with black lettering, the width of the ceiling grid, fastened by adhesive indicating the fan coil unit/blower coil unit located above the ceiling (e.g., FCU-X).

F. Refer to Specification Section 230553 for additional information.

3.11 PROTECTION OF WORK:

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping, ductwork, and equipment to prevent the entrance of water, dirt, debris, or other foreign matter.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

3.12 OPERATION OF EQUIPMENT:

A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment.

C. Do not use mechanical systems for temporary services during construction. Mechanical systems shall only be energized for testing, balancing, start-up and commissioning at times authorized by the Owner in writing.

D. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

E. If the mechanical systems are used at any time without written authorization from the Owner, other than for initial factory start-up and/or testing, balancing, and commissioning, all equipment and duct systems shall be thoroughly cleaned by this Contractor (i.e., coils, fans, variable speed drives, heat wheels, terminal units, split systems, supply, return and exhaust ducts, etc.) to restore the system and equipment to like-new condition. The Contractor is still responsible for all external cleaning to restore systems and equipment to like-new conditions. At no time will the HVAC be allowed to run when sanding, grinding, finishing, etc., type activities create dust.

3.13 IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS:

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate valve location, service, type (i.e., butterfly, globe, ball, etc.) make, model number and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under glass and hung in each Mechanical Room. Contractor shall deliver the electronic file from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. Where valves are located above ceilings, mark the ceiling grid using a small color-coded or numbered tab. Screw marker to grid.

C. All items of equipment, including motor starters, ATC panels, terminal control units, etc., shall be furnished with white letters and numbers on black plastic identification plates or aluminum letters and numbers on black engraved aluminum identification plates. Lettering shall be a minimum of 1/4" high. Identification plates shall be securely affixed to each piece of equipment, starters, panels, etc. by screws. Pressure sensitive tape backing is prohibited. Utilize the owner's coding system to match the owner's preventative maintenance system requirements. Refer to Specification Section 230553 for additional information. Coordinate with the Owner.

D. Provide three (3) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be in electronic format and bound as a volume of the "Record and Information Booklet" as hereinafter specified. Project shall not be considered "Substantially Completed" until provided.

E. All lines (piping and ductwork) installed under this contract shall be stenciled with "direction of flow" arrows and with stenciled letters naming each pipe and ductwork and service. Refer to Division 23 sections on piping. At the Contractors option, snap/strap around pre-coiled vinyl markers are acceptable.

F. Provide at least 40 hours of straight time instruction to the operating personnel. This instruction period shall consist of not less than five (5) 8-hour days. Time of instruction shall be designated by the Owner. As a minimum, three (3) additional eight (8) hour instruction times shall occur during 1) the first cooling season, 2) the first heating season, and 3) the first intermediate cooling/heating season. Additional instruction time for the Automatic Temperature Control (ATC) and Energy

Management System (EMS) is specified in Section 230900 Automatic Temperature Controls. Provide two (2) DVD-recorded or Flash Drive copies of all instructional periods/demonstrations including Automatic Temperature Control and Energy Management System. Refer to training and certification for additional requirements.

3.14 WALL AND FLOOR PENETRATIONS

A. Provide sleeves for pipes and ducts passing through roofs, floors, ceiling, walls, partitions, air handling unit casings, structural members, and other building parts. Sleeves shall extend 2" above finished floor.

B. Provide escutcheons for sleeved pipes in finished areas.

C. Piping sleeves:
1. Galvanized steel pipe, standard weight where pipes are exposed and, roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
2. Twenty-two (22) gauge galvanized steel elsewhere.
3. Hydrostatic sleeves with anchor flange for all below-grade exterior wall or floor penetrations and all PVC pipe penetrations.

D. Ductwork sleeves: 20 gauge galvanized steel at masonry walls, rated walls, at wall penetrations exposed to view, floors and roof.

E. Penetrations shall be sealed and caulked airtight for sound and air transfer control. Voids where ducts and pipes penetrate floors or other fire-rated assemblies shall be appropriately additionally fire-sealed the full depth with an approved fire sealant (3M or Dow Corning Fire Sealant Foam and Caulk). For piping, provide floor plate.

F. Where piping extends through exterior walls, provide link-seal water-proof sleeves or equivalent.

3.15 RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings. Additionally, provide one (1) electronic format (color PDF/scanned image) of all record drawings on a DVD or Flash Drive.

3.16 GUARANTEE:

A. Contractor's attention is directed to guarantee obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of guarantee shall be included in the operations and maintenance manuals. The project shall not be considered "substantially completed" until certifications are included in the Record and Information Booklets.

C. Contractor shall provide two (2) years full factory warranty on parts and labor for all equipment from the time of final acceptance of the mechanical systems by the Owner. Warranty shall include 24-hour service. Contractor shall provide a minimum of five (5) years parts and labor warranty for

all refrigeration systems (i.e., split systems/condensing units, rooftop units, pool dehumidification unit, etc.) and 10 year warranty for the VRV/VRF system including loss of refrigerant unless otherwise noted as longer. This service shall be rendered upon request when notified of any equipment malfunctions.

D. The guarantee shall not start until substantial completion has been accepted by the Owner.

3.17 LUBRICATION:

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet. Project shall not be considered “Substantially Completed” until instructions are included in the Record and Information Booklet.

B. In general, all motors and equipment shall be provided with grease-lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

C. Provide remote grease fittings with copper lube lines for air handling units and for bearings/motors where grease fittings are situated in locations as deemed by the Architect or Owner inconvenient/inaccessible for lubrication.

D. Provide pressure relief fittings at all grease lubrication locations designed to automatically vent within the range of 1/4 to 1 psi, automatically reset below this range, or another pressure relief range if the preceding differs from the manufacturer’s recommended pressure range.

3.18 RECORD AND INFORMATION BOOKLET:

A. The Contractor shall have prepared three (3) copies of the Record and Information Booklet and deliver these approved copies of the booklet to the Owner a minimum of three (3) weeks before Demonstrations. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped. The project shall not be considered “Substantially Completed” until approved.

B. The booklet shall be bound in a three-ring loose-leaf binder similar to "National" No. 3881 with the following title lettered on the front: "Record and Information Booklet (insert name of the project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pull-out.

C. Provide the following data in the booklet:
1. Catalog data on each piece of mechanical equipment furnished.
2. Maintenance operation and lubrication instructions on each piece of equipment furnished.
3. Complete catalog data on each piece of heating and air conditioning equipment furnished including approved shop drawing.
4. Manufacturers’ and Contractors' guarantees.
5. Chart form indicating time and type of routine service and maintenance of chillers, boilers, air handling units, heat recovery devices, condensing units, fan coil/blower coil units, energy recovery units, ATC System, variable speed drives, air cooled condensing units, fans, chemical treatment, unit heaters, etc. The chart shall also indicate tag number, model number of equipment, location and service. For replacement items such as filters and belts, indicate type, size and quantity of the replaceable items.

6. Provide sales and service representatives' names and phone numbers of all equipment and subcontractors.
7. Catalog data of all equipment, valves, etc., which shall include wiring diagrams, parts list and assembly drawing.
8. Provide valve chart including valve tag number, valve type, valve model number, valve manufacturer, style, service and location, etc. as specified hereinafter.
9. Copy of the approved balancing report.
10. Provide operating curves indicating design and balanced conditions for fans and pumps.
11. ATC systems, including as-built ATC drawings of systems, sequences of operation including internal devices and wiring within panels.
12. Provide an electronic data base of all equipment, including model number, location tag/identification label.
13. Provide copies of all flushing reports.
14. Provide copies of all start-up reports.
15. Provide DVD'S or Flash Drives of all demonstration and instructional periods.
16. Provide CD's/DVD's or Flash Drives of all Drawings.

D. In addition to three (3) hard copies of the data described in Paragraph C, provide three (3) electronic copies in PDF format on DVD(s) or Flash Drives of the entire O&M Manual.

3.19 LINTELS:

A. Under this Section, provide lintels not provided elsewhere which are required for openings for the installation of mechanical and plumbing work. Lintels shall meet the requirements of the Architectural and Structural Sections and The Architectural Drawings and Specifications.

3.20 EQUIPMENT BY OTHERS:

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the Contractor to obtain from the supplier of this equipment to furnish complete instructions for connections.

C. Typical equipment refers to, but is not limited to kiln hoods, kitchen equipment, etc.

3.21 FASTENERS:

A. All fasteners located in public space (toilet rooms, corridors) shall be provided with tamper-proof type fasteners.

3.22 WIRING DIAGRAMS

A. Obtain and submit wiring diagrams for all equipment provided under this Contract.

B. Wiring diagrams shall be provided with Shop Drawings, but not limited to, the following:
1. All equipment.
2. ATC System.

C. The Contractor shall submit any additional wiring diagrams as requested by the Engineer.

D. Provide wiring diagrams for all major mechanical equipment to the Electrical Contractor and the ATC Subcontractor for coordination.

3.23 BOILER AND PRESSURE VESSELS

A. All boilers and pressure vessels shall be ASME-rated and shall comply with the State of Maryland requirements.

B. Provide all control devices and materials, and install in with ASME CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

3.24 FACTORY START-UP

A. Provide factory authorized start-up service for all mechanical equipment (e.g., variable speed drives, air handling units, pool dehumidification unit, VRF System, fans, blower/fan coil units, etc.). Coordinate all start-ups with the Commissioning Agent and the Construction Manager.

B. Provide one copy of all start-up reports to the Owner and include a copy in the Record and Information Booklet.

C. Pre-Installation /Start-Up Conference:

1. The Equipment Unit Manufacturer (each) shall include in their Bid a Pre-Installation Conference, including Factory Representative(s) to review installation, EMS Integration, Sequence to Operation, and Start-Up. Coordinate all controls with the Controls Contractor prior to energizing any unit, including final commissioning of each unit with the ATC/EMS Contractor and Test & Balance Contractor. All controls and start-ups shall be by the factory (i.e., not factory-authorized start-up company).
2. The Mechanical Contractor shall include in their Bid an on-site pre-installation conference for the main mechanical equipment room to review layout and coordination of all equipment and subcontractors involved in working in the mechanical equipment room. As a minimum, the attendees need to include the following:
   a. Mechanical Contractor
   b. Electrical Contractor
   c. Building ATC Contractor
   d. Sheet Metal Contractor
   e. Owner
   f. Mechanical Engineer
   g. Commissioning Agent.
   h. Construction Manager
3. The Contractor(s) shall mark on the floors, walls, and/or ceilings, the locations of major equipment and/or penetration of systems.
4. Prior to the start of construction, the Mechanical Engineer, Owner and Architect shall review design goals, design intent, project summary, and past construction issues which should be avoided. The Mechanical Contractor shall coordinate, document, and issue minutes of the meeting. As a minimum, and in addition to the Mechanical Engineer, Owner and Architect, the attendees shall include:
   a. Mechanical Contractor
   b. Project Superintendent
   c. Commissioning Agent
   d. Electrical Contractor
   e. Building ATC Contractor
   f. Plumbing Contractor

g. Major Equipment Manufacturers' Representative(s)
h. Sprinkler Contractor

D. The Contractor shall be required to start up all systems in an orderly, organized, and coordinated manner to ensure that all systems are functioning as designed. The Mechanical Contractor shall provide a detailed start-up, testing and demonstration plan for all systems in a coordinated manner that is documented in writing at least forty-five (45) days prior to start-up. Start-up, testing, and demonstration plans shall include detailed point-by-point check list that clearly shows that systems are in face functioning as designed. As a modification to the standard AIA definition of substantial completion, the Mechanical Systems are not substantially complete until all systems are started, tested, balanced, and O&M Manuals are received by the Owner. Above listed items must be completed in time to allow for system demonstrations to the owner's Personnel with all O&M Manuals in hand at the time of demonstration. Contractors will be required to provide system demonstrations and training for the owner's Personnel for each system. At minimum, the Contractors shall provide eight (8) hours of demonstration and eight (8) hours of systems operation training for each system prior to the owner's acceptance of any given system.

3.25 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment including, but not limited to, the following:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed, noted, or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished space.
10. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of equipment components in accordance with manufacturers' recommendations. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
11. Install access panels or doors where units are concealed behind finished surfaces.
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
13. Keep all areas which are under construction under a negative pressure relative to adjacent interior spaces to create infiltration to the construction zone while preventing exfiltration of dust and odors to occupied or finished areas of the building.

3.26 CLEANING OF SYSTEMS:

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Shut-off valves serving equipment where by-pass valves have been provided shall be closed to the equipment and by-pass valves shall be open during flushing. Blow out and flush piping until interiors are free of foreign matter. Restore valves to their normal operating positions after flushing has been completed. Flushing, chemicals, sterilization, etc., shall comply with EPA Regulations and authorities having jurisdiction.

B. Flush piping in recirculating water systems to remove cutting oil, excess pipe joint compound and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of service company that was used. Project shall not be considered “substantially completed” until certificate is incorporated in the “Record and Information Booklet”.

C. Leave strainers and dirt pockets in clean condition.

D. Clean fans, ductwork, enclosures, registers, grilles, and diffusers at completion of work.

E. Install filters of equal efficiency to those specified in permanent air systems operated for testing and balancing. At no time shall the permanent equipment be used during construction except as required for testing and balancing and/or commissioning of systems, which shall be approved by the Owner. Replace with clean filters as specified prior to acceptance and after cleaning of system.

F. Pay for labor and materials required to locate and remove obstructions from systems clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

G. Leave systems clean, and in complete running order.

3.27 LOUVERS:

A. All louvers to be provided in exterior walls shall be furnished and installed under another division unless otherwise indicated on the drawings or in the specifications or by the specific scope of work as detailed by the Construction Manager. All brick vents shall be provided under this division and shall be provided with a custom color and finish as selected by the Architect. Louver shop drawings shall be submitted to the Engineer to verify sizes and free area requirements. The Contractor shall blank-off unused portions of louver with double wall insulated blank-off panels.

3.28 FILTERS:

A. Provide one (1) set of clean filters for balancing. One (1) complete set of additional filters shall be turned over to the Owner upon final acceptance of the building by the Owner. Provide correspondence documenting that additional filters have been turned over to the Owner.

B. All air handling unit pre-filters shall be 2” thick, 30% efficient (MERV 8), Camfil Farr 30/30, or as approved equal. All final filters shall be 12 thick, 65% efficient (MERV 11), Camfil Farr HP-P65 with Media Retainer Assembly, or as approved equal. Where final filters are indicated to be 4” thick, provide 65% efficient (MERV11) Camfil Farr Opti-Pac.

C. Provide MERV 11 filters for all intakes (return air grilles, outside air louvers, all AHU and terminal unit filters, etc.), if for any reason (start-up, testing and balancing, commissioning, etc.) the units are started prior to final building cleaning. Filters shall be 1", 2" or 4" thick; Camfil Farr AP-11, or as approved equal.

D. Provide one (1) differential pressure gauge across each filter bank. Differential pressure gauge shall be diaphragm activated, dial type, +/-2% accuracy of full scale, static pressure tips, aluminum tubing, vent valves, etc. Differential pressure gauge shall be Series 2000 magnahelic with air filter kit as manufactured by Dwyer or equal.

3.29 BELT GUARDS/CAGES/BELTS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery (pump coupling, plenum fans, propeller fans, etc.) Provide fully enclosed guards where machinery is exposed form more than one direction.

B. Fabricate guards of heavy gauge steel, rigidly braced, removable, and finished to match equipment served. Provide openings for tachometers. Guards shall meet OSHA requirements.

C. Provide one (1) spare set of belts for each piece of equipment. Belts shall be labeled with unit number and location. Belts shall be mounted as directed by the Owner.

3.30 ACCESS FOR INSPECTION, CLEANING AND MAINTENANCE

A. Individual finned-tube coils or multiple finned-tube coils in series without adequate intervening access space(s) of at least 18 inches (457 mm) shall be selected to result in no more than 0.75 inches wc (187 Pa) combined pressure drop when dry coil face velocity is 500 fpm (2.54 m/s). Exception: When clear and complete instructions for access and cleaning of both upstream and downstream coil surfaces are provided.

B. Equipment Clearance: Ventilation equipment shall be installed with sufficient working space for inspection and routine maintenance (e.g., filter replacement and fan belt adjustment and replacement).

C. Ventilation Equipment Access: Access doors, panels, or other means shall be provided and sized to allow convenient and unobstructed access sufficient to inspect, maintain, and calibrate all ventilation system components for which routine inspection, maintenance, or calibration is necessary. Ventilation system components comprise, for example, air-handling units, fan-coil units, water-source heat pumps, other terminal units, controllers, and sensors.

D. Air Distribution System: Access doors, panels, or other means shall be provided in ventilation equipment, duct-work, and plenums, located and sized to allow convenient and unobstructed access for inspection, cleaning, and routine maintenance of the following:
   1. Outdoor air intake areaways or plenums
   2. Mixed air plenums
   3. Upstream surface of each heating, cooling, and heat-recovery coil or coil assembly having a total of four rows or less
   4. Both upstream and downstream surface of each heating, cooling, and heat-recovery coil having a total of more than four rows and air washers, evaporative coolers, heat wheels, and other heat exchangers
   5. Air cleaners
   6. Drain pans and drain seals
   7. Fans

3.31 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.32 LIQUID LEVEL ALARM SENSORS

A. Provide liquid level alarm sensors in condensate drain pans for all cooling equipment (e.g. air handling units, dedicated outdoor air units, blower coil units, fan coil units, etc.). Sensor shall de-energize the cooling equipment and signal an alarm through the building ATC system and the county energy management system.

B. Provide additional liquid level alarm sensors where indicated on the drawings.

3.33 Carbon Monoxide Sensors

A. Provide Carbon Monoxide sensors at each indoor gas fired piece of equipment as well as in the first room, by the first diffuser for supply air systems heated by a gas furnace in accordance with State of Maryland Requirements. Interlock to monitor and alarm through the EMS and Fire Alarm system and to automatically shut down the equipment when its set point is reached. Coordinate requirements with the Electrical Contractor.

3.34 PRE SUBMITTAL MEETINGS

A. Conduct a preliminary submittal meeting at the construction manager's job site office with the engineer, owner, mechanical contractor, commissioning agent, ATC contractor, the VRV/VRF manufacturer sales representative, factory representative, and controls/integration technician prior to submitting for review the ATC system, VRF/VRV system, and air handling equipment. This meeting is for coordination between contractors and equipment suppliers to ensure a co-ordinated and fully turnkey installation.

3.35 TRAINING AND CERTIFICATION

A. Provide factory training for four (4) of the Owner's representatives in a factory training lab working with simulators for the following equipment. Training shall be a minimum of 16 hours each unless indicated otherwise as longer.

1. DOAS, AHU's, RTU's, ACCU's and pool dehumidification unit.
2. Variable Speed Drives.
3. Variable Refrigerant Volume (VRV) System (Training and Certification).
4. Automatic Temperature Control System/Energy Management System.

B. Training shall be performed by a factory-certified professional trainer for five (5) days and at a minimum shall consist of the following:

1. Controlling, cooperating, and navigating programs.
2. Maintenance diagnostics, and trouble-shooting.
3. Service repairs.

C. All training shall be on site. Coordinate all times and locations with the owner.

D. Additionally demonstrations and Training for the ATC/EMS System specified in Section 230900 “Instrumentation and Control for HVAC” shall be in addition to this requirement.

3.36 SERVICE CONTRACT

A. Under Add Alternate No. 10: Provide a five (5) year service contract for all mechanical equipment, including, but not limited to:

1. VRV System
2. DOAS Units
3. Rooftop Unit
4. Pool Dehumidification Unit
5. Air Cooled Condensing Units
6. Variable Speed Drives
7. Fans
8. Miscellaneous Heaters

B. The service contract shall include a once per year minimum checkout, recalibration, replacement of parts and recommissioning, as well as all items included in the O&M manual for servicing the specific piece of equipment.

C. Coordinate time to perform equipment servicing with the Owner.

D. Turn in all service reports to the Owner when complete.

- END OF SECTION 23 05 00 -

SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC 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.

B. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 23 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 23. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 23. All electrical work performed under Division 23 shall conform to the applicable requirements of Division 26.

C. All equipment shall have manual overrides (i.e. H-O-A switches) and phase loss protection for all three phases motors/units.

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 requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

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

D. Motors sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.

E. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.

2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.

3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.

4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than 1/2 horsepower shall be single phase, and motors 1/2 horsepower and larger shall be 3 phase.

5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

6. Brake horsepower load requirement at specified duty shall not exceed 85% of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors. For water or refrigerant cooled motors driving compressors and where other limits for certain equipment are given, the maximum load percentage shall be 78%, 72%, and 70%, for motors with 1.25, 1.35, and 1.4 service factors, respectively.

7. Unless otherwise indicated, indoor motors shall be open drip-proof with 1.15 service factors and outdoor motors shall be totally enclosed fan-cooled with 1.15 or 1.0 service factor.

D. Single phase motors, smaller than 1/20 horsepower shall be "life-time" ball or sleeve bearing; open, 120 volts, permanent-split capacitor or shaded pole type, minimum efficiency shall comply with the 2015 small motor legislation enacted by the Department of Energy. Provide ECM motors where indicated on the drawings or where specified.

E. Single phase motors 1/20 horsepower and larger, but less than 1/2 horsepower shall be "life-time" ball bearing; for outdoor service with Class A or B insulation, as standard with the motor manufacturer; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70% and a minimum full load power factor of 77%.

F. Three Phase Motors:

1. Except as otherwise specified in the various specification sections, 3 phase motors 1/2 horsepower and larger shall be NEMA Design B squirrel cage induction type meeting the requirements of this paragraph. Insulation shall be Class B or F, as standard with the motor manufacturer; at 40°C ambient temperature. Motors specified for operation at 480,

240, and 208 volts shall be nameplated 460, 230, 200 volts respectively. All motors shall be of the premium efficiency type. Efficiencies at full load for three phase motors shall be not less than the values listed below or as required by ASHRAE 90.1-2013 and IECC-2015.

Motor Nameplate	Minimum Efficiency at Nominal Speed and Rated Load -- 230/460 Volts at 1750 RPM
.74 kW (1 HP) and above to	85.5%
1-1 kW (1-1/2 HP)	86.5%
1.5 Kw (2 HP)	86.5%
2.2 Kw (3 HP)	89.5%
3.7 kW (5 HP)	89.5%
5.6 kW (7-1/2 HP)	91.0%
7.5 kW (10 HP)	91.7%
11.2 kW (15 HP)	93.0%
14.9 kW (20 HP)	93.0%
18.7 kW (25 HP)	93.6%
22.3 kW (30 HP)	94.5%
29.7 kW (40 HP)	94.5%

2. Three phase motors 1/2 HP or greater shall be the Premium Efficiency type as manufactured by Reliance Electric Company, Baldor Motor and Drives, General Electric, Lincoln, Gould, Magnetec, Toshiba, Marathon, Siemens, U.S. Electric, Leeson Electric Corporation, ABB, or approved equal. For motors serving equipment being controlled by a variable speed drive, motor shall be inverter-duty-rated and shall be provided with a shaft grounding ring.

3. Minimum full load power factor before power factor correction of horizontal and vertical shaft motors as follows:

1/2 HP	(3600 & 1800 RPM) - 70%
3/4 HP	(3600 & 1800 RPM) - 70%
1, 1-1/2 & 2 HP	(3600 & 1800 RPM) - 79%
3 HP to 250 HP	(3600 & 1800 RPM) - 85%

G. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

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

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer**.**

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

D. Provide ICM-450 under voltage, over voltage, loss of phase and phase reversal protection with time delay and auto reset for all three phase motors including all variable speed drives.

E. Provide shaft grounding ring for all motors controlled by a variable speed drive.

2.5 SINGLE-PHASE MOTORS

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

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.
5. Electronically commutated motor (ECM) or ECM as indicated.

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

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

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

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.

2.6 CAPACITORS:

A. Capacitors for power factor correction shall be provided for motors indicated on the electrical drawings and on all motors 5 HP and above. Submit capacitors with equipment which the capacitor is to be connected to. Capacitors shall be connected at the motor terminals and raise the motor power factor to a minimum of 90%. Capacitors shall be sized by motor manufacturer. Capacitors shall have integral fusing and indicating lights on all phases to give visible indication that a fuse has blown.

B. Capacitors shall not use Polychlorinated Biphenyl's (PCB) or mineral oil as a cooling medium. All capacitors shall have NEMA 1 enclosures for indoor mounting and NEMA 3R enclosures for exterior mounting.

C. Coordinate wiring connections to capacitors and motors with the electrical contractor.

D. Do not provide capacitors for motors utilizing variable speed drives.

2.7 VARIABLE SPEED DRIVE:

A. Provide variable speed controllers with disconnects for all air handling unit fans and as indicated on the drawings. Variable speed drives shall not be mounted in the airstream. Provide NEMA 3RX enclosures for outdoor installations.

B. The Adjustable Frequency Controller (AFC) shall convert three-phase 60 Hertz utility power to adjustable voltage and frequency, three phase, AC power. The AFC shall use two 32-bit microprocessors with 12-bit resolution for stepless motor control from 5% to 110% of base speed.

C. The AFC shall be a fully digital Pulse Width Modulated (PWM) output type utilizing IGBT transistors. 1-150 HP 460 Volt AFC's and 1-100 HP 208 Volt AFC's shall be current rated at 8 Khz carrier frequency. In cases where motor audible noise is not critical to the installation, an alternate 4 Khz 75 150 HP 460 Volt AFC may be supplied. All HP ratings shall meet or exceed Table 430-150 of the NEC, 3 Phase Motor Full Load Currents. HP, Maximum Current, and Rated Voltage shall appear on the AFC nameplate.

D. The AFC, together with all options and modifications, shall mount within a standard NEMA 1 enclosure for indoor applications and NEMA 3R for outdoor locations suitable for continuous operation at ambient temperature of 0 to 40 deg C at elevations up to 3300 feet altitude with relative humidity to 95% non-condensing. All high voltage components within the enclosure shall be isolated with steel or polycarbonate covers. The complete unit shall be UL approved and ULJ 508 labeled. The AFC and options shall comply with the applicable requirements of the latest standards of ANSI, NEMA, NEC, NEPU-70, IEEE519-1992, FCC Part 15, Subpart J, CE96. The AFC Manufacturer shall be ISO 9001 certified.

E. Circuits shall provide DV/DT and DI/DT protection for semi-conductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:
   1. Motor current exceeds 110% of controller maximum sine wave current rating for longer than one minute.
   2. Motor current exceeds 200% of controller maximum sine wave current rating.
   3. Output phase-to-phase short circuit condition.
   4. Total ground fault under any operating condition.
   5. High input line voltage.
   6. Low input line voltage.
   7. Loss of input or output phase.
   8. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, firestat, etc., to shut down the drive.

F. The following adjustments shall be available in the controller and retained in non-volatile memory:
   1. Maximum frequency (15 to 120 Hz), factory set at 60 Hz.
   2. Minimum frequency (5 to 60 Hz).
   3. Acceleration (0.1 to 999.9 seconds).

4. Deceleration (0.1 to 999.9 seconds).
5. Volts/Hertz ratio, factory set for 460 V at 60 Hz or 208 volts at 60 Hz.
6. Current limit (50% to 110% sine wave current rating), factory set at 100% current.

G. The AFC shall have the following basic features:

1. Door-mounted operator controls consisting of a membrane command center which allows manual stop/start and speed control, local/remote status indication, manual or automatic speed control selection, and run/jog selection. In addition, the command center will serve as a means to configure controller parameters such as minimum speed, maximum speed, acceleration and deceleration times, volts/Hz ratio, torque boost, slip compensation, overfrequency limit, and current limit. Potentiometers will not be allowed for these settings. The controller shall have an internal means of deactivating keypad parameter adjustments to eliminate unauthorized data entry.
2. Main input disconnect to provide a positive disconnect of all phases of the incoming A-C line to the controller and to the bypass circuitry when bypass is provided. This disconnect shall be mounted inside the controller enclosure and have through-the-door interlocking toggle with provisions for padlocking.
3. Electronic motor overload relay.
4. Automatic restart after power outage or drive fault, with drive-in automatic mode. The circuit shall allow the user to select up to (10) restart attempts as well as the dwell time between attempts. The reset time between fault occurrences shall also be selectable. All settings shall be via the membrane command center.
5. Door-mounted LED display for digital indication of:
   a. Frequency output.
   b. Voltage output.
   c. Current output.
   d. Time-stamped fault indication.
   e. Motor RPM.
   f. Input kW.
   g. Elapsed time.
   h. DC bus volts.
6. Relay contacts for remote indication of drive fault and motor running.
7. Smoke purge circuit to enable user-supplied contacts to force controller to a preset adjustable speed when energized.
8. Three critical frequency avoidance bands, field programmable via the membrane command center. Each critical frequency avoidance band shall have a bandwidth adjustable via keypad entry of up to 10 Hz.
9. Eight programmable present speeds which will force the AFD to a preset speed upon a user contact closure.
10. Electronic isolated process follower to enable VFD to follow a 0-20 mA, 4-20 mA or 0-4, 0-8, 0-10 volt D-C grounded or ungrounded signal.
11. The AFC shall have the capability to ride through power dips up to 10 seconds without a controller trip depending on load and operating condition.
12. Isolated 0-10 V or 4020 mA output signal, selectable for speed or current.
13. RS-232 Port for configuration, control, and monitoring.
14. A slip compensation circuit for accurate 1% speed regulation without the need of a tachometer.
15. Capability for direct communications with open BACnet Building Automation Systems. Fault diagnostics, start/stop, speed commands, and all drive feedbacks shall be available over a single communications module. Discrete signals such as Bypass Run or Interlock Open shall be mapped through the drive terminal strip to the BAS.
16. Manual bypass-to-line with magnetic contactors to transfer motor from the variable frequency controller to full speed operation on utility supplied input power, or from utility power to the controller, while the motor is at zero speed. Two motor

contactors, electrically interlocked shall be utilized, one contactor between the controller output and the motor and the other between the bypass power line and the motor, providing across-the-line starting.

17. Provide interface card for open BACnet Energy Management System. Provide interface requirements to meet sequence of operation and I/O Summary requirements.

H. Motor protection per National Electrical Code shall be provided in both the "controller" mode and the "bypass" mode by a single bi-metallic motor overload relay. The 1156 volt A-C relay control logic, allowing common Start/Stop commands in the "controller" mode and the "bypass" mode shall also be included within the enclosure.

I. The bypass shall include a door interlocked main power input disconnect providing positive shutdown of all power to both the bypass circuitry and the VFD. The bypass circuit shall also include a second input disconnect to the VFD. This disconnect shall provide the ability to safely trouble shoot and test the controller, both energized and de-energized, while operating the bypass mode.

J. Input line fuses to provide protection for the input rectification circuit, using Class J fuses with interrupting rating of 200,000 AIC. The series interrupting rating of the AFC and fuses shall be a minimum of 30,000 AIC and shall be stated in the AFC Instruction Manual as required by UL.

K. Three percent impedance Input Line Reactor to minimize line surges, line notching, and voltage distortions.

L. The VFD and all components shall be supplied in a NEMA 1 enclosure when mounted indoors, NEMA 3RX enclosure for outdoors and shall be UL Listed as a single unit. Do not mount VSD's inside the unit within the airstream.

M. The VFD Manufacturer shall maintain and staff nationwide service centers. These service engineers shall be employed by the Manufacturer and provide start-up service including physical inspection of drive and connected wiring and final adjustments to meet specified performance requirements.

N. The VFD and motor shall carry a full parts and labor warranty for five (5) years from the date of substantial completion.

O. Motors shall be premium efficiency and specifically designed for operation with VFD's. Coordinate with equipment manufacturers.

P. The variable speed drive shall be manufactured by ABB Model ACH-550, Yaskawa, or Danfoss.

PART 3 - EXECUTION (Not Applicable)

- END OF SECTION 23 05 13 -

SECTION 23 05 29
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 "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
3. Division 23 Section(s) "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.

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

D. Shop Drawings: 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.

E. 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.

F. Welding certificates.

1.5 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 stainless steel or zinc-plated carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components. Provide felt or wool inserts.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel or zinc-plated carbon 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 stainless steel or zinc-plated 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. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.
   c. Flex-Strut Inc.
   d. GS Metals Corp.
   e. Thomas & Betts Corporation.
   f. Unistrut Corporation; Tyco International, Ltd.
   g. 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 or zinc-coated stainless steel.
7. Metallic Coating: Hot-dipped galvanized.
8. Paint Coating: Rust-inhibiting paint.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by Anvil International, Figure 45 Channel Assembly or comparable product by one of the following:
   a. Empire Industries, Inc.
   b. ERICO International Corporation.
   c. Haydon Corporation; H-Strut Division.
   d. PHD Manufacturing, Inc.
   e. PHS Industries, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes. Standard: Comply with MFMA-4.
3. Channels: Continuous steel channel assembly with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel or zinc-coated carbon steel.
6. Coating: Rust-inhibiting paint or galvanized.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by Anvil International, Figure 45 Channel Assembly, or comparable product 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.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Rilco Manufacturing Co., Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water repellant-treated, ASTM C 533, Type 1, with 100 psig minimum compressive strength or ASTM C 552, Type II cellular glass with 100-psig (688-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, 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.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components (galvanized or stainless steel supports and

stainless steel fasteners, rods, nuts, washers, attachments, etc.) 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. 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. All supports shall be hot-dipped galvanized construction with stainless steel rods, fasteners, etc.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes. All supports shall be hot-dipped galvanized construction with stainless steel rods, fasteners, etc.

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.

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.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) 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 (DN 100) 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 (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.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) 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.

O. Pipe hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the Structural Engineer. Do not support all parallel piping from the same bar joist (pipe sizes 3-inches and larger) unless approved by the Structural Engineer.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

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 (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.

D. Paint all (exposed and concealed) gas piping yellow.

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 or inserts on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use painted or zinc-coated carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general interior service applications. Use galvanized or stainless steel pipe hangers and supports, trapeze pipe hangers, and framing systems and attachments for exterior 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 non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
4. 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. 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 Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
3. 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.
4. 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.
5. 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.
6. 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 instead of building attachments where required in concrete construction.

R. Regardless of spacing, hangers shall be provided at all changes in direction, both vertical and horizontal, for all piping.

S. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction.

For piping located in and supported from the building structure, hanger spacing and rod sizes for steel and copper pipe shall not be less than the following for horizontal piping:

Nominal Pipe Size Inches	Maximum Span Feet		Minimum Rod Diameter inches of ASTM A36 Steel Threaded Rods
	Standard Steel Pipe	Copper Tube	
3/4 & 1	6	5	3/8
1 – 1/4	6	6	3/8
1-1/2	8	6	3/8
2	8	8	3/8
2-1/2	8	8	1/2
3	10	10	1/2
4	10	10	5/8
5	10	10	5/8
6	12	12	3/4
8	12	12	7/8
10	14	12	7/8
12	14	12	7/8

- END OF SECTION 23 05 29 -

SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS 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. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Freestanding and restrained air-mounting system.
12. Restrained vibration isolation roof-curb rails.
13. Restraining braces and cables.
14. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

A. 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. Wind-Restraint Loading:
1. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

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

B. Welding certificates.

C. Qualification Data: For engineer and testing agency.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 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. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 SUMMARY

A. Provide all labor and materials necessary to furnish and install vibration control systems on this project as herein specified and/or shown on the drawings.

B. Mount all mechanical equipment on suitable vibration isolators so as to prevent transmission of vibration into or through the building structure. Isolators shall be as manufactured by Mason Industries, Inc., Amber/Booth, Kenitics, or Peabody, and shall be selected by the isolator manufacturer for each item of equipment in accordance with requirements hereinafter specified.

C. The equipment manufacturer shall supply all pump and motor bases, fan and motor bases, cradles, pipe/duct hangers, spring and/or neoprene isolators, neoprene pads, flexible connectors, etc., as a coordinated package by a single manufacturer.

D. Select isolators for uniform static deflections according to distribution of weight; and for not less than the indicated isolation efficiency with the lowest rotational speed of equipment as the disturbing frequency.

E. Isolators and bases shall be stable during stopping and starting of equipment without transverse or eccentric movement of equipment, and shall be designed to resist horizontal forces of equipment which may operate unbalanced.

F. In general, select isolators on the basis of criteria as specified in the ASHRAE Applications Handbook, Latest Edition.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Indusries, or a comparable product by one of the following:
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control.

B. Pads: Arranged 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 rubber, Mason Super W.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range, Mason Type No.

   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators – Mason Model SLF: 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- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators – Mason Type SLR: 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- (6-mm-) 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.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.

H. Elastomeric Hangers Mason Type HD: Single or 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.

I. Spring Hangers Mason Type 30N: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

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

J. Spring Hangers with Vertical-Limit Stop – Mason Type PC30N: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 THRUST RESTRAINTS

A. Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" movement at start and stop. The assembly shall be furnished with one rod and angle bracket for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit. Horizontal thrust restraints shall be Type WB.

2.3 FLEXIBLE CONNECTORS FOR PIPING

A. General: Straight flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

B. Metal Flexible Connectors: Fabricated of grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover. Sizes 3" and larger shall be flanged. Sizes 2-1/2" and smaller shall have male nipples. Lengths shall be as indicated:

NOMINAL DIAMETER (INCHES)	LENGTH (INCHES)
1/2”	9”
3/4”	10”
1”	11”
1-1/4”	12”
1-1/2”	12”
2”	12”
2-1/2”	12”
3”	18”

NOMINAL DIAMETER (INCHES)	LENGTH (INCHES)
4”	18”
5”	18”
6”	18”
8”	18”
10”	18”
12”	18”
14”	18”
16”	18”

C. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Type BSS.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails. Mason Type WF and Mason Type ICS.

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.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. 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.

C. Inertia Base- Mason Industries BMK/KSL bases with modular corners: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

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.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel modular corner brackets on frame for isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.5 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 galvanized 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.

2.6 ACOUSTICAL FLOOR, CEILING AND WALL SEAL:

A. Provide acoustical floor, ceiling, and wall seal where piping passes through mechanical equipment room/fan and air handling unit room walls, floors, or ceilings, and any noise-sensitive areas. The vibration isolator manufacturer shall provide a split seal consisting of two bolted pipe halves with 3/4” or thicker neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240ºF, 10# density fiberglass shall be used in lieu of the sponge. Seals shall be Type SAWS.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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 will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).

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

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

E. 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.

F. 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.

G. 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 piping where they cross expansion and/or 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 Division 22 and 23 for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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. Test and adjust air-mounting system controls and safeties.
10. 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 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.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 GENERAL PROVISIONS

A. Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

B. Where neoprene elements of vibration isolator may be subjected to high pipe temperatures above 160 deg F, provide metal heat shields or thermal isolators.

C. A minimum of 4" thick concrete housekeeping pads shall be provided under all floor mounted equipment unless indicated otherwise. A minimum of 6" thick concrete housekeeping pads shall be provided under all air handling units, chillers, boilers and where indicated on the drawings. Rest sub-bases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least one (1) inch clearance between sub-bases and inertia bases, steel bases, and steel saddles with machinery in operation. Provide a minimum of 3” thick perlite concrete (30-35 PCF) in all curb spaces for roof mounted air handling equipment.

D. All vibration isolators exposed to weather shall be hot dipped galvanized with springs coated with neoprene.

E. Concrete inertia bases shall be a minimum of two (2) times the weight supported. Clearance between the underside of the inertia base and the housekeeping pad below shall not be less than 1 inch. Concrete shall be 3000 psi. Install inertia bases in accordance with the recommendations of the machinery manufacturer and the inertia base manufacturer.

F. Anchor Bolts and Grout: Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

G. Common Machinery Foundations: Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

H. Vertical Stops: For machinery affected by wind pressure or having an operational weight different from installed weight, provide resilient vertical limit stops which prevent spring extension when weight is removed. Provide vertical stops for machinery containing liquid, such as water chillers, evaporative coolers, boilers, and cooling towers. Spring isolated or protected spring isolated machinery must rock and move freely within limits of stops or seismic restraint devices.

I. Thrust Restraints: Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

J. Machinery: Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.

K. Stability: Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

L. Lateral Motion: The installed vibration isolation systems for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than 1/4-inch. Restrain motions in excess by approved spring mountings.

M. Unbalanced Machinery: Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

N. Non-Rotating Machinery: Mount non-rotating machinery in systems which include rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

O. Unitized Machinery Assemblies: Unitized assemblies such as chillers with evaporator and condenser, and top mounted centrifugal compressor or unitized absorption refrigeration machines, structurally designed with end supports, may be mounted on steel rails and springs in lieu of steel bases and springs. Where the slab or deck is less than 4 inches thick, provide spring isolation units with the deflection double that of the vibration isolation schedule, up to a maximum static deflection of 5 inches.

P. Roof and Upper Floor Mounted Machinery: On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA ASMM Plate 61.

Q. Vibration isolation ceiling hangers shall be installed so that the hanger rods do not touch the sides of the isolator housing, thereby seriously degrading the vibration isolation performance. Vibration isolation ceiling hangers shall be located so that the hanger housing may rotate 360º without touching any object.

R. Electrical Connections: Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

S. Systems Not to be Vibration Isolated: Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

3.8 PIPE ISOLATION:

A. Horizontal Pipe Isolation
   1. Precompressed Suspension Spring Isolators: The first three pipe hangers in the main lines near the mechanical equipment provide precompressed suspension spring isolators. Floor supported piping shall rest on trained spring isolators. All precompressed suspension spring isolators hangers or the first three trained spring isolators mounts as noted above, will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceiling under occupied spaces, the first three hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1.5" deflection for pipe sizes up to and including 6" and 2.5" deflection thereafter. All other hangers and mounts will have a minimum steel spring deflection of 0.75". Hangers shall be located as close to the overhead supports as practical.
   2. Combination Spring and Neoprene Suspension Hanger: For horizontal runs in Mechanical Equipment Rooms (including Air Handling Unit Rooms) other than those hereinbefore specified, provide suspension spring hangers (combination spring and neoprene) with .75" minimum steel spring deflection.

B. Floor-Supported Piping:
   1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described hereinbefore and selected to the guidelines of hangers.

2. The first three adjacent floor supports shall be the restrained spring type with a blocking feature that prevents load transfer to equipment flanges as the piping is filled and drained.
3. Where piping is subject to larger thermal movement a slide plate shall be installed on the top of the isolator. Slide plate shall be teflon, graphite or steel.
4. Provide a thermal barrier where neoprene products are installed directly beneath steam or hot water lines.

C. Pipe Risers: Provide pipe riser supports with bearing plates and two layers of 1/4" thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4" steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

D. Supports at Base of Pipe Risers: Piping isolation supports at the base of risers shall be two layers of 1/2" thick heavy-duty neoprene pad separated by 1/4" thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

E. Pipe Anchors: Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum 1/2" thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.9 EQUIPMENT ROOM SOUND ISOLATION:

A. Do not allow direct contact between pipes or ducts and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.

B. Pipe Penetrations: All piping passing through Mechanical Equipment Room and Fan/Air Handling Unit Room walls, floors and ceilings shall be protected against sound leakage by means of an acoustical wall seal as described hereinbefore.

C. Duct Penetrations: Provide with sound insulation equal to the sound attenuation value of the wall, floor, or ceiling penetrated.

3.10 FLEXIBLE PIPE CONNECTORS:

A. Provide flexible connectors in accordance with Manufacturers instructions where piping systems serving vibration isolated equipment and as shown on the drawings. Flexible connectors shall be installed near the connection to the equipment.

3.11 ISOLATION FOR SPECIFIC EQUIPMENT:

A. The vibration isolator manufacture shall provide isolators for all pieces of equipment provided for the job. Isolator shall be selected by the isolator manufacturer on the basis of criteria as

specified in the latest edition of ASHRAE Applications Handbook, unless a more stringent requirement is indicated on the drawings.

B. Cabinet/In-Line Fan(s): Suspended – Provide combination spring and neoprene type isolator with a minimum deflection of 1.00"; Mason Industries Type 30N, or approved equal.

C. Cabinet Unit Heaters and Fan Coil Units (Ceiling Hung Type): Provide combination spring and neoprene isolator, Mason Type W30, at 1.00" minimum deflection.

D. Roof Mounted Air Handling Equipment: Provide Kinetics ESR Vibration Isolator Curb with 1" static deflection combination spring and neoprene isolators. Additionally provide 4" thick, light weight (30 PCF) acoustical concrete (Perlite) within entire curb space.

E. Air Cooled Condensing Units: Install on a restrained combination spring and neoprene isolator with 1" static deflection, Kinetics FLSS.

F. All exterior vibration isolators shall be galvanized or coated by the manufacturer to prevent rust

- END OF SECTION 23 05 48 -

SECTION 23 05 53
IDENTIFICATION 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. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 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.

1.4 COORDINATION

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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths 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, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

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

2.3 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, snap-on semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive (4" and less). For larger pipe (sizes 6" and greater) markers shall be strapped around using nylon ties.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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 1-1/2 inches (38 mm) high.

D. Underground Piping: Detectable warning tape shall consist of a nominal 4.5 mil (.0045") overall thickness, with a solid aluminum foil core. The imprinted warning message is "Buried, or Encased" to prevent ink rub-off, and is impervious to acids, alkalis and other destructive elements found in soil. The imprint is as such that it allows for total reflectivity. A tape must be visibly seen before it can be read.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME (ANSI) A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Aluminum.
2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, alkyd enamel in colors according to ASME (ANSI) A13.1 unless otherwise indicated.

B. Duct Identification Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, 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. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) black-filled letters for piping system abbreviation and 1/2-inch (13-mm) numbers; 2-inch diameter.

1. Tag Material: Brass, 19-gauge, minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass jack chain and/or brass S Hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 4 by 7 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: 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 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 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 (ANSI) A13.1, on each piping system.

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

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

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

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
8. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner to be easily legible from the floor.
9. For piping less than 3/4-inch, provide permanently legible tag as specified hereinbefore for valve identification.
10. For buried piping, provide 2-inch minimum width plastic identification/detection tape with metallic core. Install 4-6-inches below-grade.

D. Pipe Label Color Schedule:

1. Refrigerant Piping:

a. Background Color: Black.
b. Letter Color: White.

3.4 DUCT LABEL IDENTIFICATION

A. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, shall be provided.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 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 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. Refrigerant: 2 inches (50 mm), round.

2. Valve-Tag Color:
a. Refrigerant: Black.

3. Letter Color:
a. Refrigerant: White.

3.6 WARNING-TAG INSTALLATION

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

3.7 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   1. Fuel-burning units, including boilers, furnaces, heaters, and hot water units.
   2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   3. Heat exchangers, coils, evaporators, heat recovery units, and similar equipment.
   4. Fans, blowers, primary balancing dampers, and mixing boxes.
   5. Packaged HVAC central-station and zone-type units.

B. Install equipment signs with two screws and permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.

   1. Signs shall have white letter on a red background.
   2. Letter Size: ½ inch.
   3. Nameplate Size: ½ inch high x minimum 6 inch length.
   4. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   5. Equipment Name Destination: Provide four part label (or as required by the Owner) consisting of the following:

      RCS-(Equipment Symbol)-(Equipment Number)-(Room Number)

      Example: Fan Coil “FCU-107” located in Conference Room 107 shall be identified:

      RCS-FCU-107-107

C. Install access panel markers with screws on equipment access panels.

3.8 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow:

   1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pre-tensioned pipe markers. Use size to ensure a tight fit.
   2. Pipes with OD, Including Insulation 6 inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.

3.9 GAS PIPING

All gas piping shall be painted yellow.

- END OF SECTION 23 05 53 -

SECTION 23 05 93

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.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Domestic hot water system.

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 SUBMITTALS

A. Qualification Data: Within 30 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 30 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. Sample report forms.

F. 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.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.

B. TAB Conference: Meet with Architect, Owner, Commissioning Agent, Construction Manager and Engineer 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 14 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 Architect, Owner, Construction Manager, Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations. After occupancy no activities are permitted during normal school operating hours.

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.

C. The project will have all systems fully commissioned by an independent Commissioning Company.

1.7 COORDINATION

A. Notice: Provide fourteen days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

C. Coordinate all testing and balancing with the Commissioning Agent.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. All testing and balancing shall be performed by an independent test and balance agency that specializes in and whose business is limited to the testing and balancing of mechanical systems. The agency must have membership in the “Associated Air Balance Council” or “NEBB” and have an Engineer certified by the National Examining Board. All final reports shall be signed and officially stamped by the certified test and balance engineer.

B. Subject to compliance with requirements, engage one of the following available TAB contractors that may be engaged include, but are not limited to, the following:
   1. Baltimore Air Balance Company.
   2. Baumgartner, Inc.
   3. American Testing, Inc.
   4. Chesapeake Testing and Balancing Engineers, Inc.
   5. Weisman, Inc.
   6. Butler Balancing Company, Inc.
   7. Flood and Sterling, Inc.
   8. WAE Balancing.
   9. Eastern Air Balance.
   10. Precision Balancing.
   11. Annandale Balancing Company

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine 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.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. 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.

I. Examine terminal units, such as space fan coil units, and verify that they are accessible and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. 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.

3.3 REQUIREMENTS

A. Test and balance all heating, ventilating, and air conditioning systems. The work shall include, but not be limited to, the following:

B. Witness all leak tests for ductwork and air distribution systems.

C. Balance and adjust all air distribution systems (including air terminal devices) to within 5% of design air quantities, including maximum and minimum heating, cooling, and set-points of air handling units.

D. Adjust all fans to required speeds for design air flow, including changing sheaves.

E. Test the capacity and performance of all equipment and adjust to design conditions.

F. Operate and test all systems under all sequences of operation and adjust equipment and controls for efficient and stable operation.

G. Test and balance all systems under adequate load conditions. If, in the opinion of the Engineer, there is insufficient load to properly test and balance the systems, perform sufficient preliminary balancing and adjustment to permit operation of the systems until such time as final testing and balancing can be done.

H. Retest or rebalance the systems as required during the guarantee period.

I. Provide water and air test and balance for all air handling systems (AHU's, DOAS units, BCU's). Retest and rebalance all equipment at the completion of the project.

3.4 COORDINATION BY THE MECHANICAL CONTRACTOR

A. Coordinate the testing and balancing work with the work of other trades.

B. Furnish complete and up-to-date contract documents, shop drawings, installation and coordination drawings, submittal data, and other information to the testing and balancing agency so that the work is performed using all required system and equipment data.

C. Plan and schedule testing and balancing at required times during construction. Review all plans, schedules, and procedures with the Engineer before proceeding.

D. Prepare all systems for testing and balancing. Provide clean filters in all air systems and clean strainers and traps in the piping systems. Provide final flushing of piping systems if required.

E. Make all necessary adjustments and repairs to the work, correcting any malfunctions or deficiencies which are disclosed by testing and balancing.

3.5 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.6 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", ASHRAE 111, SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section, NEBB Procedural Standards.

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.

3.7 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."

3.8 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

   a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet 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 and heat-recovery equipment, 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 Architect, Owner, Construction Manager, 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 within specified tolerances.

1. Measure airflow of submain and branch ducts.

   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.9 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure for the critical terminal (heat pump) unit.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal unit at maximum airflow and adjust static pressure sensor to deliver the designed maximum airflow. When total airflow is correct, balance the air outlets downstream from terminal (heat pump) units the same as described for constant-volume air systems.
5. Set terminal units airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

3.10 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.
9. For variable flow systems develop a plan to simulate diversity (i.e. heating system coils are sized based on heat wheel failure).

3.11 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers or ECMS: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.12 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.13 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.

5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.14 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.
2. Air Outlets and Inlets: Plus or minus 5 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Geothermal-Water Flow Rate: Plus or minus 10 percent.

B. Provide preliminary system level TAB reports on completed systems to support commissioning.

3.15 REPORTING

A. Initial Construction-Phase 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 biweekly 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.

3.16 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 and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units 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.
m. Vortex 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. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).
o. Inlet steam pressure in psig (kPa).

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. 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).

K. 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.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.17 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 5 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 Architect, Owner, Engineer, Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect, Owner, Engineer, Commissioning Authority.
3. Architect, Owner, Engineer, 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.

3.18 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

- END OF SECTION 23 05 93 -

SECTION 23 07 00
HVAC 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:

1. Insulation Materials:
   a. Flexible elastomeric.
   b. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied fabric-reinforcing mesh.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.
14. Corner angles.

B. Related Sections:
1. Division 22 Section "Plumbing Insulation."
2. Division 23 Section "Metal Ducts" for duct liners.

1.3 SUBMITTALS

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

B. LEED Submittals: Comply with Section 018813

1. MR Credit 2: BPDO – Environmental Product Declarations
   a. For insulations, if available: Product specific declaration or Industry-wide EPD or product specific EPD.

2. MR Credit 4: BPDO – Materia Ingredients
   a. For insulation, if available: Material Ingredient Report.

3. MR Credit 3: BPDO – Sourcing of Raw Materials

   a. For bio-based insulation: Manufacturer letter on company letterhead stating raw material supplier's compliance with Sustainable Agriculture Network's (SAN) Sustainable Agriculture Standard, including a link to a publicly available document confirming SAN compliance, dated within one year of LEED project registration. Include statement indicating percentage by weight of the total assembly that is bio-based. Include material cost.
   b. For recycled content insulation: Documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include material cost value.

4. EQ Credit 2: Low emitting materials

   a. For interior we applied welding solvent, cement adhesives, sealants, paints and coatings: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method V1.1 – 2010 and VOC content in g/l. Include volume of material applied per product.

C. Shop Drawings:

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.
8. Detail field application for each equipment type.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:

   a. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
   b. Sheet Form Insulation Materials: 12 inches (300 mm) square.
   c. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).
   d. Sheet Jacket Materials: 12 inches (300 mm) square.
   e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

E. Qualification Data: For qualified Installer.

F. 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.

G. Field quality-control reports.

1.4 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting 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.

1.5 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.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

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

1.7 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 Part 3 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. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Aeroflex USA Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

G. 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 II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Duct Wrap.
d. Owens Corning; All-Service Duct Wrap.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Johns Manville; HTB 23 Spin-Glass.
b. Owens Corning; High Temperature Flexible Batt Insulations.

I. 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 ASJ. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one 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.

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Fibrex Insulations Inc.; FBX.
    b. Johns Manville; 1000 Series Spin-Glas.
    c. Owens Corning; High Temperature Industrial Board Insulations.
    d. Rock Wool Manufacturing Company; Delta Board.
    e. Roxul Inc.; Roxul RW.
    f. Thermafiber; Thermafiber Industrial Felt.

K. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Fibrex Insulations Inc.; Coreplus 1200.
    b. Johns Manville; Micro-Lok.
    c. Knauf Insulation; 1000 Pipe Insulation.
    d. Manson Insulation Inc.; Alley-K.
    e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied - SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied - SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

4. Products: Subject to compliance with requirements, provide one of the following:

    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.
    c. Knauf Insulation; Pipe and Tank Insulation.
    d. Owens Corning; Fiberglas Pipe and Tank Insulation.

L. Removable ATC Vale Insulation Wrap: Insulated factory fabricated removable and reusable cover. Outer jacket shall be made of Dupont Tychem QC or equal, overlapping and completely covering the insulation with seams joined by tabs made from hook and loop fasteners (i.e. Velcro). Butt ends shall have sewn-in place elastic. Insulation shall have a minimum K-factor. 26, using fiberglass blanket, a minimum of 1” thick for line sizes 1-1/2” and smaller, 1-1/2” thick for line sizes over 2”. Flame and smoke spread shall be 25/50 per SSTM E-84. No sweat or equal.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C 656,

Type II, Grade 6. tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, provide the following:

   a. Johns Manville; Super Firetemp M.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
   d. Thermal Ceramics; FireMaster Duct Wrap.
   e. 3M; Fire Barrier Wrap Products.
   f. Unifrax Corporation; FyreWrap.

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

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA Inc.; Aeroseal.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.

2. Interior wet applied adhesives: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

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

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-82.
   b. Foster Products Corporation, H. B. Fuller Company; 85-20.
   c. ITW TACC, Division of Illinois Tool Works; S-90/80.
   d. Marathon Industries, Inc.; 225.
   e. Mon-Eco Industries, Inc.; 22-25.

2. Interior wet applied adhesives: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

D. ASJ Adhesive, and 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 of the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

2. Interior wet applied adhesives: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Dow Chemical Company (The); 739, Dow Silicone.
b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Speedline Vinyl Adhesive.

2. Interior wet applied adhesives: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

2.4 MASTICS

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

1. Interior wet applied mastics: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-35.
b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Marathon Industries, Inc.; 590.
e. Mon-Eco Industries, Inc.; 55-40.
f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) 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, 59 percent by volume and 71 percent by weight.
5. Color: White.

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-30.
b. Foster Products Corporation, H. B. Fuller Company; 30-35.
c. ITW TACC, Division of Illinois Tool Works; CB-25.

d. Marathon Industries, Inc.; 501.
e. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; Encacel.
b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
c. Marathon Industries, Inc.; 570.
d. Mon-Eco Industries, Inc.; 55-70.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) 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, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-10.
b. Foster Products Corporation, H. B. Fuller Company; 35-00.
c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
d. Marathon Industries, Inc.; 550.
e. Mon-Eco Industries, Inc.; 55-50.
f. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
4. Solids Content: 63 percent by volume and 73 percent 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 250 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 Products, Division of ITW; CP-52.
b. Foster Products Corporation, H. B. Fuller Company; 81-42.
c. Marathon Industries, Inc.; 130.
d. Mon-Eco Industries, Inc.; 11-30.

e. Vimasco Corporation; 136.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-76-8.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.

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. Interior wet applied sealants: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

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

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; 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 (Minus 40 to plus 121 deg C).
5. Color: White.
6. Interior wet applied sealants: Comply with low–emitting requirements in Division 01, Section “Sustainable Design Requirements LEED”.

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: White, kraft-paper, or paper-free (Owens Corning Evolution) fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

1. Products: Subject to compliance with requirements, available products that may be incorporated into the work, but are not limited to, the following::

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.9 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; 20 mil thickness; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
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.

5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 Temper H-14.

a. Factory cut and rolled to size.
b. Stucco embossed finish and thickness shall be based on the outer diameter of the insulation system per the requirements of ASTM-C1729 but not less than .024”.
c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and Surlyn Polymers.
d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers(ITW ELL-Jacs Plus):

1) Same material, finish, polyfilmed lined 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.

2.10 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 of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
b. Compac Corp.; 110 and 111.
c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
b. Compac Corp.; 130.

c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
d. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
b. Compac Corp.; 120.
c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.11 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing or closed seal.
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm), wide with wing or closed seal.
4. 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. Cupped-Head, Capacitor-Discharge-Weld Pins: Stainless steel- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.

2. 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 of the following:

      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: Zinc-coated, low carbon steel, aluminum or stainless steel, fully annealed, 0.106-inch- (2.6-mm-) 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.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- thick, galvanized-steel or stainless steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

   a. Products: Subject to compliance with requirements, provide one 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.

      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 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy or 0.062-inch (1.6 mm) soft annealed stainless steel..

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

      a. C & F Wire.
      b. Childers Products.
      c. PABCO Metals Corporation.
      d. RPR Products, Inc.

2.12 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment 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. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: 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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade 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 equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and 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- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.

   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.

2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

Q. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance such as vessel covers, fasteners, flanges, frames and accessories.

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 (50 mm) 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 (50 mm).
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. 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 (50 mm).

1. Comply with requirements in Division 07 Section "Joint Firestopping" and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. 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 (50 mm).

2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.6 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 reusable valve wraps. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
10. Heating hot water coil piping trim to terminal units (blower coil units, VAV units) does not need to be insulated if located a minimum of three (3) feet from the coil when located in air conditioning ductwork.
11. Insulate all heating coils and all connecting piping within 3 feet of coil when located in air conditioning ductwork.
12. All valve stems shall be sealed with caulking.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. 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 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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 reusable valve wrap covers.

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 MINERAL-FIBER INSULATION INSTALLATION

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 (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but 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 (25 mm), 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.

E. 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 100 percent 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) 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 (10 deg C) at 18-foot (5.5-m) 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 2 times the insulation thickness but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) 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- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

F. 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 100 percent 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) 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 (10 deg C) at 18-foot (5.5-m) 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 2 times the insulation thickness but not less than 3 inches (75 mm).

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- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

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 (50-mm) overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) 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 (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.10 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.11 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two 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 coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.12 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(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, 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(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
3. 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 locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three 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.

3.13 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/relief located in nonconditioned space.
4. Indoor, exposed return/relief located in nonconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, relief / exhaust upstream and downstream from heat recovery units/devices.
7. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
8. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
9. Outdoor, concealed supply and return.
10. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1, unless otherwise indicated.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.14 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

D. Concealed, round and flat-oval, exhaust-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

E. Concealed, rectangular, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

F. Concealed, rectangular, return/relief-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

G. Concealed, rectangular, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

H. Concealed, rectangular, exhaust-air duct insulation to and from heat recovery units and all exhaust air duct insulation between isolation damper and penetration of building exterior shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct, Range Hood Exhaust and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

J. Concealed, supply-air plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

K. Concealed, return/relief-air plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

L. Concealed, outdoor-air plenum insulation shall be the following:

   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

M. Concealed, exhaust-air plenum insulation shall be the following:

   1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

N. Exposed, round and flat-oval, supply-air duct insulation shall be the following:

   1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

O. Exposed, round and flat-oval, return-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

P. Exposed, round and flat-oval, outdoor-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

Q. Exposed, round and flat-oval, exhaust-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

R. Exposed, rectangular, supply-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

S. Exposed, rectangular, return/relief-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

T. Exposed, rectangular, outdoor-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

U. Exposed, rectangular, exhaust-air duct insulation shall be the following:

1. Exposed ductwork in occupied spaces does not require external insulation. Exposed ductwork shall be double wall pre-insulated.

V. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct, Range Hood exhaust and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

W. Exposed, supply-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

X. Exposed, return/relief-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

Y. Exposed, outdoor-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

Z. Exposed, exhaust-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

AA. Concealed supply air and return/relief/exhaust air ductwork insulation for heat recovery air handling units shall be the following for the first ten (10) feet of the unit connection:
1. Double Wall pre-insulated and provided with external insulation.

2. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

3.15 OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Exposed ductwork insulation shall be the following:
   1. Double Wall pre-insulated and provided with external insulation.
   2. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

3.16 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

3.17 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 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.

3.18 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):

   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
      b. Flexible Elastomeric: 1 inch (25 mm) thick.

B. Refrigerant Suction and Hot-Gas Piping:

   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch (25 mm) thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:

   1. All Pipe Sizes: Insulation shall be the following:

      a. Flexible Elastomeric: 1 inch (25 mm) thick.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 2 inches (50 mm) thick.
   b. Mineral-Fiber, preformed pipe insulation, Type I: 2 inches (50mm) thick

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:

   a. Flexible Elastomeric: 2 inches (50 mm) thick.
   b. Mineral-Fiber, preformed pipe insulation, Type I: 2 inches (50mm) thick

3.20 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 material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:
   1. White. Venture Clad 1579CW

E. Equipment, Concealed:

1. None.

F. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
   1. White. Venture Clad 1579CW

G. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
   1. White. Venture Clad 1579CW

H. Piping, Concealed:

1. None.

I. Piping, Exposed:
   1. PVC: 20 mils (0.5 mm) thick.

3.21 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. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ductwork, Exposed:
   1. Venture Clad 1579CW

D. Piping, Exposed and all insulated exterior piping:
   1. Aluminum, Stucco embossed with Z-Shaped Locking Seam: 0.024 inch (minimum) thick.
   2. Aluminum 2-piece tee and fitting covers: .024-inch thickness.

- END OF SECTION 23 07 00 -

SECTION 23 08 00
MECHANICAL SYSTEM COMMISSIONING

PART I – GENERAL

1.01 WORK INCLUDED

A. Systems and equipment testing and startup.
B. Completion of Pre-FPT Installation Checks.
C. Validation of proper and thorough installation of Division 23 systems and equipment.
D. Systems balancing verification.
E. Performance Verification Testing of equipment and systems.
F. Functional Performance Testing of equipment and systems.
G. Documentation of tests, procedures, and installations.
H. Coordination of Training Events.
I. Generic Startup Procedures for mechanical systems and equipment.

1.02 GENERAL DESCRIPTION

A. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
B. Commissioning Authority (CA) is retained by the Owner and shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.
C. This Section outlines the Cx procedures specific to the Division 23 Contractors. Commissioning requirements common to all Sections are specified in Section 01 19 13, Section 01 19 15, the individual specifications and the Commissioning Plan.

1.03 SCOPE

A. LEED requires that all features in the Water Efficiency and in the Energy and Atmosphere and most of the Indoor Environmental Quality areas are appropriately commissioned. The following equipment, systems, assemblies and features will be commissioned utilizing the traditional construction phase commissioning process that includes submittal review, construction checks, testing, observation, and training and documentation verification. All general references to equipment in this document refer only to equipment that is to be commissioned. The responsibility for developing and reviewing forms, overseeing, documenting and witnessing execution and reviewing reports of checks and tests is distributed among constructors and designers and differs for different equipment types.
B. Mechanical/HVAC Systems
   1. Dedicated Outdoor Air Systems
   2. Packaged Outdoor Central Station Air Handling Units
   3. Heating Ventilation Unit
   4. Air Cooled Condensing Units – VRF
   5. Variable Refrigerant Terminal Units
   6. Ductless Split Systems
   7. Kitchen Makeup Air Unit and Hood Exhaust
   8. Cabinet Unit Heaters
   9. Propeller Unit Heaters
   10. Fin Tube Radiation
   11. Exhaust Fans / Power Ventilators

C. Building Automation Systems
   1. Analyze trends
   2. Verify Standalone Capability of Controllers
   3. Verify BMS Interface, Software, Graphics, and Functions
   4. Verify Integration with DOAS Units, Heat Pumps and RTUs
   5. Verification of Miscellaneous Points

1.04 RELATED WORK AND DOCUMENTS

A. Commissioning Plan: The Commissioning Plan outlines the commissioning process beyond the construction specification. All Contractor responsibilities are outlined in Specifications. Commissioning Plan is available to the Contractor to understand the context of their responsibilities but does not define any additional responsibilities of the Contractor
B. The following section names and numbers will vary with each project. Edit them accordingly. This is one of the most challenging efforts to ensure that the requirements are incorporated in the project. Use this as a reminder of the sections to check/edit to properly incorporate the Cx procedures and requirements.
C. Section 01 33 00 – Submittals: Addresses documentation and procedures relative to the submittal process, including Operation and Maintenance Manuals.
D. Section 01 50 00 – Temporary Utilities: Specifies the requirements for using Owner's existing and/or permanent equipment and controls for temporary conditioning in the facility.
E. Section 01 77 00 – Project Close Out: Defines the milestones in completion incorporating the commissioning process.
F. Section 01 19 13 – General Commissioning Requirements: Details the Cx requirements common across all Divisions beginning with the Construction Phase. Focus is on Contractors' responsibilities for the Cx process.
G. Section 01 19 15 – Commissioning Functional Performance Testing: Provides 'generic' functional performance testing procedures to illustrate the level-of-effort expected during acceptance testing.
H. Individual Sections in the Various Divisions: Individual sections stipulate installation, startup, warranty and training requirements for the system or device specified in the section.
I. Section 23 08 59 – Instrumentation and Control System Commissioning: Details the commissioning procedures specific to the ATC/EMS System.

1.05 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 19 13 and the Commissioning Plan.

1.06 REFERENCE STANDARDS

A. ASHRAE Guideline 1.1-2007, "HVAC&R Technical Requirements for the Commissioning Process"
B. ASHRAE Guideline 4-2008, "Preparation of Operating and Maintenance Documentation for HVAC&R Systems"
C. NEBB - Procedural Standards for Building Systems Commissioning

1.07 DOCUMENTATION

A. In addition to the documentation required in Section 01 19 13, Contractor shall provide to the Commissioning Authority the following per the procedures specified herein, in the Commissioning Plan, and in other sections of the specifications:
   1. Balancing Plan: The plan shall include the following:
      a. Certifications for all instrumentation to be used throughout the testing. This must document certification within the last 6 months.
      b. Résumés and Certification of individuals who will be balancing systems.
      c. Detailed step by step plans for each procedure to be performed.
      d. Sample forms to be used for each measurement.
      e. Sample balancing report.

2. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports should be provided in PDF electronic format. These may include but are not limited to:
    a. Variable Refrigerant Systems
    b. Energy Recovery Units
    c. Rooftop Units (DOAS)
    d. Variable Frequency Drives
    e. Fan Capacity
    f. Fan Sound Power Levels
    g. Domestic Hot Water Generators
    h. Pump Capacity
3. Field Testing Agency Reports (other than TAB): Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in PDF electronic format. These may include but are not limited to:
    a. Pipe Pressure Testing
    b. Duct Leakage Testing
    c. Vibration Testing
    d. Generated Noise and Resultant Noise Level
    e. Water Treatment
4. Completed Test and Balance Reports: Commissioning Authority will review prior to FPT.

1.08 SEQUENCING AND SCHEDULING

A. Refer Section 01 19 13 and the Commissioning Plan.

1.09 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 19 13 and the Commissioning Plan but shall be refined and documented in the Construction Phase Cx Kick-Off meeting. Contractor shall have input into the protocols and all parties will commit to scheduling obligations. The Commissioning Authority will record and distribute.

1.10 CONTRACTOR RESPONSIBILITIES

A. Refer to Section 01 19 13: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 19 13. The following are additional responsibilities or notable responsibilities specific to Division 23.

B. Construction Phase
    1. Provide skilled technicians qualified to perform the work required.
    2. Provide factory-trained and authorized technicians where required by the Contract Documents.
    3. Prepare and submit required draft Startup Procedures and submit along with the manufacturer's application, installation and startup information.
    4. TAB: Specifically, as it relates to Cx:
    5. Attend Cx kick-off meeting and Cx progress meetings held within 2 months of and during Acceptance Phase.
    6. Submit Balancing Plan as indicated above.
    7. Meet with Cx Team to review TAB procedures and documentation required.
    8. As requested by Commissioning Authority, participate in Commissioning Team demonstrations of balancing procedures for repetitive procedures such as zones.
    9. Provide all documentation electronically.
    10. On airflow tracking zones:
        a. Balance all outlets downstream of VAV terminal. Record final settings
        b. Measure airflow at both minimum and maximum flow conditions and calibrate VAV flow signals at both extremes. Extremes of flow shall be established by putting the

zone into full heating and full cooling. Record all parameters and final flow coefficient. If only one flow coefficient is available, and this does not permit setting the range to within specified tolerances, enter the flow coefficient the average of the two required flow coefficients and report the deficiency in an Action Item.

c. Measure and record supply air flow at flow extremes with reheat valves both open and closed as required above.

C. Acceptance Phase

1. Assist Commissioning Authority with Performance Verification and Functional Performance Testing. Assistance will generally include the following:
   a. Manipulate systems and equipment to facilitate testing (as dictated in Section 01 19 13 and the Commissioning Plan;
   b. Provide any specialized instrumentation necessary for functional performance testing;
   c. Manipulate ATC/EMS and other control systems to facilitate functional performance testing as dictated in sections 01 19 13, 01 19 15, 23 08 59, and the Commissioning Plan.

D. Warranty Phase

1. Maintain record documentation of any configurations, set ups, parameters, etc. that change throughout the period.
2. Provide representative for off season testing as required by Commissioning Authority.
3. Respond to Warranty issues as required by Division 1 and the General Conditions.

1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

A. Refer to Section 01 19 13.

1.12 CONTRACTOR NOTIFICATION AND SCHEDULING

A. Refer to Section 01 19 13.

1.13 STARTUP PROCEDURES AND DOCUMENTATION

A. Refer to Section 01 19 13.

1.14 ATC/EMS TRENDING REQUIREMENTS

A. Trending requirements are specified in Section 01 19 13 and Section 23 08 59.

1.15 PERFORMANCE VERIFICATION TESTING

A. Contractor shall participate in Performance Verification Testing as stipulated in Section 01 19 13 and Section 01 19 15.

1.16 FUNCTIONAL PERFORMANCE TESTING

A. Contractor shall participate in Functional Performance Testing as stipulated in Section 01 19 13 and Section 01 19 15.

1.17 FPT ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in Sections 01 19 13 and 01 19 15, and in the specification sections applicable to the systems being tested. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device.

1.18 TRAINING

A. Contractors, Subcontractor, Vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 19 13 and the individual Specifications.

1.19 SYSTEMS MANUAL CONTENT

A. Refer to Section 01 19 13 the individual Specifications.

PART 2 – PRODUCTS

2.01 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
   1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of +/- 0.1°F.
   2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
   3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems shall be provided by the Commissioning Authority.

C. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

2.02 *CxWorx* SOFTWARE

A. General: CxWorx is a web-based software program that supports the commissioning process through a web browser or Android Application. It allows multiple Parties to collaborate on commissioning information management using the Internet to either enter data or synchronize local copies of the project data held on tablets provided by the CxA with the master project database. CxWorx facilitates either completing information directly via the software or by printing forms to fill out in the field. Refer to the Commissioning Plan for further details on CxWorx.

B. Participation: Mechanical, Electrical, TAB, and ATC/EMS Contractors shall participate in the use of CxWorx to document the Cx procedures.

C. Requirements for Use: Refer to Section 01 19 13.

D. CxWorx Training: Refer to Section 01 19 13.

2.03 TEST KITS FOR METERS AND GAGES

A. Test kits for meters and gages shall be provided to the Owner new and in good condition. Previously used kits will be unacceptable. Kits shall be submitted prior to the Acceptance Phase. Kits included shall be as a minimum:
   1. Digital indication of temperature and pressure with associated sensors to work with the P/T test ports
   2. Companion readout kit (with fittings) for calibrated balancing valve with ranges as required by all devices on this project

PART 3 – EXECUTION

3.01 STARTUP PROCEDURES – GENERAL

A. This Section outlines 'generic' or minimally acceptable Startup Procedures (delineated as Startup Checks and Startup Tests) and individual systems training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per standard quality control practices.

These items shall provide a minimum or guideline for required Contractor development of Startup Procedures. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized Startup Procedures specific to the equipment and systems installed on this project.

3.02 PROCEDURES COMMON TO ALL SYSTEMS

A. The following start up verifications/procedures are common to all systems
B. Checkout shall all sensors and system components.
C. Verify labeling is affixed per specifications and visible.
D. Verify prerequisite procedures are complete.
E. Inspect for damage and ensure none is present.
F. Verify system is applied per the manufacturer's recommendations.
G. Verify system has been started up per the manufacturer's recommendations.
H. Verify that access is provided for inspection, operation and repair.
I. Verify that access is provided for replacement of the equipment.
J. Verify the record drawings, submittal data and O&M documentation accurately reflect the installed systems.
K. Verify all gages and test ports are provided as required by contract documents and manufacturer's recommendations.
L. Verify all recorded nameplate data is accurate.
M. Installation is done to ensure safe operation and maintenance.
N. Verify specified replacement material/attic stock has been provided as required by the Construction Documents.
O. Verify all rotating parts are properly lubricated.
P. Verify all monitoring and ensure all alarms are active and set per Owner's requirements.

3.03 VALVES

A. Startup Checks: Perform the following checks during startup and as specified in manufacturer's instructions:
   1. Operate all valves, manual and automatic, through their full stroke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
   2. Verify actuators are properly installed with adequate clearance.
   3. Verify all valves are labeled per the construction documents. Confirm that concealed valves are indicated on the finished building surface.
   4. For automatic pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable. For electronically operated valves, check the stroke and range. For all automated valves controlled by a program, ensure that the minimum and maximum stroke and ranges on the valves are coordinated with the limits entered in the program.

3.04 METERS AND GAGES

A. Startup Checks: Perform the following checks during startup and as specified in manufacturer's instructions:
   1. Adjust faces of meters and gages to proper angle for best visibility.
   2. Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gages requiring temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure threads are clean and that connection can be made easily.
   3. Meters and gages requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

3.05 MECHANICAL IDENTIFICATION

A. Startup Checks: Perform the following checks:

1. Verify all valve tags, piping, duct, and equipment labeling corresponds with drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
2. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
3. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.06 MECHANICAL INSULATION

A. Startup Checks: Examine all piping, systems and equipment specified to be insulated.
   1. Ensure quality of insulation. Patch and repair all insulation damaged after installation.
   2. Ensure the integrity of vapor barrier around all cold surfaces.

3.07 PIPING - GENERAL

A. Startup Checks: These Procedures apply to all installed piping systems, including underground site utilities.
   1. Inspect all piping for proper installation, adequate support (with appropriate vibration isolation where applicable) and adequate isolation valves for required service.
   2. Submit welding certifications as required by the applicable specification section or referenced ASME specification.
   3. Submit certified welding inspection results per the applicable specification section or referenced ASME specification. ASME B31.1 requires 100% inspection based on pressure class.
   4. Provide notification of pipe cleaning and flushing activities.
   5. Flush and clean all piping and clean all strainers. Provide documentation of all related procedures.
   6. Ensure adequate drainage is provided at low points and venting is provided at high points.
   7. Ensure air is thoroughly removed from the system as applicable. Ensure facilities to effectively drain and fill the system are in place.
   8. Ensure all piping is adequately supported and anchored to allow expansion. Bump across-the-line pumps and inspect for excessive pipe movement.
   9. Provide notification of pressure testing.
   10. Pressure and/or leak test all applicable systems in accordance with the requirements in the applicable sections, ASME B 31.1 and 39.1 as applicable.
   11. Sterilize applicable piping systems as specified in the individual Sections and as required by regulatory authorities.
   12. Submit pressure test reports that document the pressure testing results with Certification of the results.
   13. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation.
   14. Set and adjust fill, pressure, or level controls to the required setting.

3.08 AC MOTORS

A. Startup Checks: Perform the following checks during startup and as specified in manufacturer's instructions:
   1. Verify proper alignment, installation, and rotation.
   2. Verify properly sized overloads are in place.
B. Startup Tests: Perform the following tests, measurements, or procedures during startup and as specified in manufacturer's instructions:
   1. Measure insulation resistance, phase balance, and resistance to ground.
   2. Measure voltage available to all phases. Measure amps and RPM after motor has been placed in operation and is under load.
   3. Record all motor nameplate data.

3.09 BEARINGS

A. This applies to all bearings on fans, pumps, compressors, etc.
B. Use infrared thermometer to measure temperature at peak conditions. Ensure temperature is below manufacturer's recommendations.
C. Check alignment as applicable.
D. For bearings in drives with motors over 10 HP, use a vibration meter and measure the maximum peak to peak acceleration. Compare it to the "Vibration Severity Chart". Rectify any condition causing conditions indicated as "Rough" or worse.
E. Lubricate all bearings per the manufacturer's instructions. When bearing is used for temporary conditioning, lubricate on manufacturer's recommended frequency and document it.

3.10 VARIABLE SPEED DRIVES

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
B. Startup Checks: Perform the following checks before startup and as specified in manufacturer's startup instructions:
   1. Check unit for shipping damage.
   2. Perform a point-to-point continuity test for all field installed wiring interconnections. Verify terminations of field installed wiring.
   3. Check for proper torque on connections.
   4. Verify use of shielded cable where specified and check that shields have been terminated properly.
   5. Verify grounding.
   6. Check motor nameplate against drive input rating.
   7. Manually rotate motor shaft to ensure free rotation.
   8. Check that motor leads are not grounded.
C. Startup Tests: Perform the following tests, measurements, or procedures during startup and as specified in manufacturer's instructions:
   1. Ensure device and system which drive is serving is configured to withstand the device operation specified below.
   2. Adjust the Minimum Voltage Adjustment to enable starting but not to draw excessive power at start.
   3. Adjust the Volts/Hz adjustment to proper setting.
   4. Adjust the Acceleration and Deceleration rates to the specified times.
   5. Adjust Current Limiting to coordinate with the overcorrect device and protect the motor.
   6. Set the Maximum and Minimum speed pots.
   7. Manually ramp fan speed from minimum to maximum and check for excessive noise and vibration.
   8. Determine any critical speeds to avoid and set these in the drive.
   9. Check for acceptable voltage and current distortion on the power system. Record the input and output voltages and currents showing the harmonic content as a percentage of the base frequency.
   10. Measure and record overall efficiency at 50%, 75%, and 100%.
   11. Record the motor terminal voltage.
D. Training: Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.
   1. Review data in Operating and Maintenance Manuals.

3.11 HYDRONIC PIPING

A. Startup Checks: Perform the following checks:
   1. Prepare hydronic and test piping in accordance with applicable Section and ASME B 31.9 and/or B 31.1.
   2. Flush system with clean water in accordance with applicable Section.
   3. Clean strainers.

4. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
5. Set automatic fill valves for required system pressure.
6. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
7. Set and coordinate automatic fill pressure and relief valve settings

B. Startup Tests: Perform the following tests, measurements, or procedures during startup:
1. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.12 VARIABLE REFRIGERANT VOLUME AIR COOLED CONDENSING UNITS

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
B. Refer to AC Motors in this section
C. Startup Checks: Perform the following inspections/checks before startup:
1. Ensure unit is level.
2. Coils are undamaged, and fins are combed.
3. Condenser fan rotates freely and check rotation direction.

D. Startup Tests: Perform the following before or during startup:
1. Startup condensing units, in accordance with manufacturer's startup instructions.
2. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
3. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.13 ROOFTOP HEATING AND COOLING UNITS (DOAS UNITS)

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
B. Refer to AC Motors in this section
C. Startup Checks: Perform the following inspections/checks before startup:
1. Ensure unit is level.
2. Coils are undamaged, and fins are combed.

D. Startup Tests: Perform the following before or during startup:
1. Startup units in accordance with manufacturer's startup instructions.
2. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
3. Test for leaks. Repair leaks and replace lost refrigerant and oil.
4. Install new filters after start up.

E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.14 CENTRAL STATION AIR HANDLING UNITS

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
B. References: The following additional Sections shall also apply:
   1. Refer to AC Motors in this Section.
   2. Refer to Fans in this Section.
   3. Refer to Section 23 05 93 "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
   4. Refer to Section 23 08 59 for procedures for starting the controls related to the AHU.
C. Startup Checks: Perform the following inspections/checks before startup:
   1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
   2. Cleaning: Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
   3. Adjust and lubricate dampers and linkages for proper damper operation.
   4. For field fabricated units, ensure the sections are properly connected within acceptable tolerances.
   5. Seal the all penetrations air tight and ensure access doors seat tightly.
   6. Verify unit is secure on mountings and supporting devices and verify connections for piping, ductwork, and electrical are complete.
   7. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
   8. Ensure vibration isolation integrity is maintained throughout the AHU installation and its connections.
   9. Tension all belts per the drive manufacturer’s recommendations.
   10. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
   11. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
   12. Comb coil fins for parallel orientation.
   13. Install clean filters.
   14. Ensure condensate drains properly and that trap is adequate.
   15. Stroke all valves and dampers to ensure free and full travel
D. Startup Tests: Perform the following before or during startup:
   1. Pressure test units as required in the AHU specification
E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
   1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
   2. Familiarization with contents of Operating and Maintenance Manuals.

3.15 VARIABLE REFRIGERANT TERMINAL UNITS
A. Refer to and coordinate with Section "Testing, Adjusting, and Balancing"
B. Startup Checks: Perform the following inspections/checks before startup:
   1. After construction is completed, including painting if applicable, clean unit exposed surfaces.
   2. Clean factory-finished surfaces. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
   3. Ensure unit is properly supported and that integrity of vibration isolation has been maintained where applicable.
   4. Ensure air inlet is free of obstructions. Start fans and ensure proper rotation (as applicable). Measure and record motor amperage and voltage.
   5. Ensure the coils are undamaged, combed, and vented.

6. Check the heating and cooling devices and control to ensure functionality and proper installation.

C. Startup Tests: Perform the following before or during startup:
1. Install new filters where required.
2. Set all temperature and humidity set points to those as directed by Owner.
3. Record supply air temperature at full cooling and at full heating (compare both with current air handler temp)

3.16 FANS

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. References: The following additional Sections shall also apply:
1. Refer to AC Motors in this Section.
2. Refer to Bearings in this Section.
3. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
4. Refer to Division 23 08 59 Section “Instrumentation and Control System Commissioning” for procedures for starting the controls related to the Fan.

C. Startup Checks: Perform the following inspections/checks before startup:
1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
3. Adjust and lubricate dampers and linkages for proper damper operation.
4. Verify unit is secure on mountings and supporting devices and that the connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
5. Ensure vibration isolation integrity is maintained with the fan installation and the connections to it.
6. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
8. Stroke all dampers to ensure free and full travel.

D. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.17 METAL DUCTWORK

A. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

B. Startup Checks: Perform the following checks before startup and as specified:
1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
2. Strip protective paper from stainless ductwork surfaces if applicable, and repair finish wherever it has been damaged.

C. Startup Tests: In addition to specifications, perform the following as a minimum:

1. Leakage Tests: After each duct system which is constructed for duct classes over 3" is completed, test for duct leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than 1% of system design air flow.
2. Balancing: Refer to Division 23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

3.18 FABRIC DUCTWORK

A. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.
B. Storage: Store inside and protected from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.
C. Startup Checks: Perform the following checks before installation and as specified:
   1. Clean air handling unit and metal ductwork internally of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of facing or coating.
   2. If fabric ductwork becomes soiled during installation, they should be removed and cleaned following the manufacturers published terms of laundering methods.

3.19 DUCTWORK ACCESSORIES

A. Startup Checks: Perform the following checks before startup and as specified:
   1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
B. Startup Tests: In addition to specifications, perform the following as a minimum:
   1. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.
   2. Label access doors in accordance with Division 23 section "Mechanical Identification".
   3. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
   4. Final positioning of manual dampers is specified in Division 23 section "Testing, Adjusting, and Balancing".
   5. Fire Damper Testing: For every fire damper, remove the fusible link and verify that the damper operates freely and closes tightly. Reinstall the fusible link.

3.20 BUILDING AUTOMATION AND CONTROL SYSTEMS

A. Startup Checks: Perform the following checks before startup and as specified:
   1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
B. Startup Tests: Refer to Section 23 08 59. This generally requires manufacturers authorized representative to startup, test, adjust, and calibrate direct digital and other microprocessor-based control systems and demonstrate compliance with requirements. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.

3.21 TESTING, ADJUSTING, AND BALANCING

A. Reference: Perform testing and balancing procedures on each system identified in accordance with Section 23 05 93 and detailed procedures outlined in individual specification sections and the referenced standards.
B. Startup Checks: In addition to specifications, perform the following as a minimum:
   1. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

2. Patch insulation, ductwork, and housings, using materials identical to those removed.
3. Seal ducts and piping, and test for and repair leaks.
4. Seal insulation to re-establish integrity of the vapor barrier.
5. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
6. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.
7. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

3.22 ROOM / ZONE / PHASE CHECKOUT

A. Contractor shall complete a checklist acknowledging completion of Division 23 responsibilities for all areas and equipment relevant to testing. Checklist shall include items such as the following as applicable:

B. Typical Room:
   1. Diffuser, registers, and grilles installed and cleaned.
   2. Zone Control in place and functional.
   3. All terminal equipment functional, clean, and punched out.
   4. Occupancy schedules entered with applicable control set points.

- END OF SECTION 23 08 00 -

SECTION 23 08 59
INSTRUMENTATION AND CONTROL SYSTEM COMMISSIONING

PART I – GENERAL

1.01 WORK INCLUDED
- A. EMS/ATC System and equipment testing and start-up.
- B. Validation of proper and thorough installation of EMS/ATC systems and equipment.
- C. Functional testing of control systems.
- D. Documentation of tests, procedures, and installations.
- E. Coordination of EMS/ATC training.
- F. Documentation of EMS/ATC Operation and Maintenance materials.

1.02 GENERAL DESCRIPTION
- A. This section defines responsibilities of the Automatic Temperature Control (ATC) and Energy Management System (EMS) Contractor defined in 23 09 00 to Commission the ATC/EMS systems.
- B. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- C. Commissioning Authority (CA) is retained by the Owner shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.
- D. This Section outlines the Cx procedures specific to the Division 23 Contractors. Requirements common to all Sections are specified in Section 01 19 13.

1.03 SCOPE
- A. The scope of the Commissioning on this project shall include all EMS and ATC systems.

1.04 RELATED SECTIONS:
- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Commissioning Plan: The Commissioning Plan outlines the commissioning process beyond the construction specification. All Contractor responsibilities are outlined in Specifications. Cx Plan is available to the Contractor to understand the context of their responsibilities but does not define any additional responsibilities of the Contractor
- C. Section 01 19 13 – General Commissioning Requirements: details the Cx requirements common across all divisions
- D. Section 01 19 15 – Functional Testing Procedures: Outlines the generic functional testing procedures required.
- E. Section 23 08 00 – HVAC Systems Commissioning: Details the commissioning procedures specific to HVAC (Division 23) work.
- F. Section 23 08 59 – Instrumentation and Control Systems Commissioning: Details the commissioning procedures specific to the EMS and ATC Systems.

1.05 DEFINITIONS AND ABBREVIATIONS
- A. Refer to Section 01 19 13.

1.06 REFERENCE STANDARDS
- A. ASHRAE Guideline 1.1-2007, "HVAC & R Technical Requirements for the Commissioning Process"

B. ASHRAE Guideline 4-2008, “Preparation of operating and Maintenance Documentation for Building Systems”
C. NEBB - Procedural Standards for Building Systems Commissioning
D. LEED v4 for Building Design and Construction released in 2013.

1.07 CONTRACTOR RESPONSIBILITIES

A. General responsibilities of the Contractor are specified in Section 01 19 13. The following responsibilities indicate specific responsibilities of the EMS/ATC contractor in addition to those responsibilities
B. Assist CxA in verification and performance testing. Assistance will generally include the following:
   1. Establish trend logs of system operation as specified herein
   2. Manipulate systems and equipment to facilitate functional performance testing as outlined in Section 01 19 15 and the Commissioning Plan. This will typically only be for initial samples of like systems if the proper level of EMS/ATC system access is granted to the Commissioning Authority.
   3. Provide Portable Operator Terminals or operator workstations in locations convenient to testing activities as specified below
   4. Provide CxA with appropriate passwords, keys, and access to control panels and workstations.
   5. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing
C. Provide a Control technician to work at the direction of Commissioning Authority for software optimization assistance for a minimum of 16 hours. Refer to Part 3 for a description of the software optimization.
D. Provide a form summarizing all set points and alarm parameters and alarming strategies for the Owner to complete. Organize a meeting to discuss the desired initial set points and alarm parameters. Contractor shall enter the requested set points and alarm parameters at completion of startup and record the applicable settings in the pre-functional documentation.
E. Train Owner’s Representatives in system’s operation and control equipment use, operation, maintenance and repair. Training shall be conducted as follows:
   1. Control system training shall be conducted by the Control Subcontractor. Control system training shall be as specified in Part - 3 of this section.
F. Compensate the Owner for site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures which require on-site time for retesting will be considered actual damages to the Owner. The contract sum shall be reduced by contract modification at a negotiated rate per man-hour of on-site time necessary to retest failures. All parties under contract with the Owner who are affected by the retesting shall be included in the contract modification. Refer to Section 01 19 13 and 01 19 15 for more details.

1.08 SEQUENCING:

A. Refer Section 01 19 13.
B. The following list outlines the general sequence of events for Commissioning of the Control systems.
   1. Construction Phase:
      a) Collaborate on construction scheduling
      b) Submit Product data and Shop Drawings and receive approval.
      c) Meet with Cx Team to coordinate with all trades
      d) Begin controls installation.
      e) Submit refinement of generic pre-functional checklists incorporating manufacture specific start-up procedures accompanied by manufacturers pre-printed start up procedures for all equipment provided by the EMS/ATC contractor
      f) Receive EMS/ATC pre-functional checklists approval.

g) Submit Training Plan content
h) Receive approval of Training Plan content
i) Provide alarm list and receive approval
j) Provide sample graphics and receive approval
k) Complete EMS/ATC system installation
l) Place systems under EMS/ATC control.
m) Enter alarms as approved by Owner
n) Complete EMS/ATC graphics
o) Perform EMS/ATC system start up and complete pre-functional documentation.
p) Submit completed EMS/ATC pre-functional Checklists
q) Prepare and initiate Trend Log data storage and format trend graphs.
r) Train Owner on control system operation and maintenance for basic system offering.
s) System Turn Over Meeting
t) Submit Commissioning EMS/ATC Software/Access and provide password access to Owner and commissioning authority.
u) R9eceive EMS/ATC pre-functional documentation approval and approval to schedule Commissioning Demonstrations.
v) Demonstrate systems to Commissioning Authority and Owner.
w) Submit trend logs in format specified
x) Receive Demonstration approval and approval to schedule Acceptance Phase.

2. Acceptance Phase
   a) Operational Testing.
   b) Receive Operational Test approval which enables start of Functional Testing.
   c) Commissioning Authority Performs Functional Performance Testing and EMS/ATC contractor participates in initial samples.
   d) Receive Functional Completion approval for the EMS/ATC.
   e) Substantial Completion.
   3. Warranty Phase
   a) Provide administrator access password access to Owner.
   b) Train Owner on final Sequences and modes of operation.
   c) Update facility manual content with any changes.
   d) Revise and Re-Submit Record drawings and O&M manuals.
   e) Install Framed Control Drawings
   f) Final Completion.
   g) Opposite Season Operational Test and Functional Performance Testing.
   h) Receive Opposite Season Operational Test and FPT approval.
   i) Revise and Re-Submit Record drawings and O&M manuals.
   j) Update Framed Control Drawings.
   k) Complete owner training.
   l) End of Warranty Period

PART 2 - PRODUCTS

2.01 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
   1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or - 0.1°F.
   2. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
   3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CA.
C. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

2.02 *CxWorx* SOFTWARE

A. General: CxWorx is a web-based software program that supports the commissioning process through a web browser or Android Application. It allows multiple Parties to collaborate on commissioning information management using the Internet to either enter data or synchronize local copies of the project data held on tablets provided by the CxA with the master project database. CxWorx facilitates either completing information directly via the software or by printing forms to fill out in the field. Refer to the Cx Plan for further details on CxWorx.
B. Participation: Mechanical, Electrical, TAB, and EMS/ATC Contractors shall participate in the use of CxWorx to document the Cx procedures.
C. Requirements for Use: Refer to Section 01 19 13.
D. CxWorx Training: Refer to Section 01 19 13.

2.03 TEST KITS FOR METERS AND GAGES

A. Test kits for meters and gages shall be provided to the Owner new and in good condition. Previously used kits will be unacceptable. Kits shall be submitted prior to the Acceptance Phase. Kits included shall be as a minimum:
   1. Digital indication of temperature and pressure with associated sensors to work with the P/T test ports
   2. Companion readout kit (with fittings) for calibrated balancing valve with ranges as required by all devices on this project

2.04 TAB & COMMISSIONING PORTABLE OPERATORS TERMINAL

A. Provide the CxA with all software, connection devices, licenses, passwords, etc. to facilitate connection to the EMS/ATC throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period. Options include:
   1. One laptop computer provided by EMS/ATC Contractor for dedicated use by the CxA throughout the Construction and Acceptance Phases.
   2. Browser access to the full graphic software. CxA will provide laptop however EMS/ATC contractor shall set up the laptop to successfully connect. A minimum of three simultaneous license seats must be provided.
   3. Licensed Client Software to be installed on CxA Computer. EMS/ATC contractor shall install the software and ensure it is functional.
   4. Terminal Services session access to a Graphic server with required CALs to allow use of all required software. EMS/ATC contractor shall configure the CxA computer to connect to the terminal session. A minimum of three simultaneous license seats must be provided.
B. Access to the EMS/ATC must be provided throughout the building defined as follows:
   1. Full wireless connection to the graphic server throughout the building will be adequate.
   2. Network connection for full access to the graphic server within 50’ of any point in the building
   3. Exception to 1 and 2 above: an acceptable alternative to full building access to the graphic server relating to terminal controls shall be providing to the CxA the devices and software required to connect to local terminal controllers through a connection port in the

space such as connection to a jack on the temperature. This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.

C. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator's terminal. Any manufacturer specific hardware such as connection cables, converters, hand held devices, etc. shall be provided by the contractor.

D. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.

PART 3 – EXECUTION

3.01 EMS/ATC START-UP, TESTING, ADJUSTING, CALIBRATION

A. Work and/or systems installed under Division 23 shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:

1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
2. Verify proper electrical voltages and amperages and verify that all circuits are free from faults.
3. Verify integrity/safety of all electrical connections.
4. Coordinate with TAB subcontractor and CA to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB contractor, and note any TAB deficiencies in the EMS/ATC Start-Up Report:
   a) Optimum duct static pressure set points for VAV air handling units.
   b) Minimum outside air damper settings for air handling units.
   c) Optimum differential pressure set points for variable speed pumping systems.
   d) Calibration parameters for flow control devices such as VAV boxes and flow measuring stations.
   e) EMS/ATC contractor shall provide hand held device as a minimum to the TAB and CA to facilitate calibration. Connection for any given device shall local to it (i.e.: at the VAV box or at the thermostat). HHD or portable operator's terminal shall allow querying and editing of parameters required for proper calibration and start up.
5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the EMS/ATC display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the EMS/ATC Start-Up Report.
6. Check and set zero and span adjustments for all transducers and transmitters.
7. For dampers and valves:
   a) Check for adequate installation including free travel throughout range and adequate seal.
   b) Where loops are sequenced, check for proper control without overlap
8. For actuators:
   a) Check to ensure that device seals tightly when the appropriate signal is applied to the operator.
   b) Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
   c) For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate

per manufacturer's procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.

d) Check the stroke and range under actual loading conditions and validate that they correlate with programmed values

e) For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.

9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device.
10. For outputs to reset other manufacturers devices (VFDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
11. Verify proper sequences by using the approved checklists to record results. Verify proper sequence and operation of all specified functions.
12. Verify that all safety devices trip at appropriate conditions. Adjust set points accordingly.
13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the EMS/ATC Start-Up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within three minutes of any set point challenge (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
    a) Duct air temperature: ±1°F.
    b) Space Temperature: ±2°F within 3 minutes and control within ±1°F
    c) Chilled Water: ±1°F
    d) Hot water temperature: ±2°F.
    e) Duct pressure: ± 0.25" w.g.
    f) Water pressure: ±1 psid
    g) Duct Humidity: ±3% when adding humidity
    h) Space Humidity: ±5% when adding humidity to control
    i) Terminal Air flow control: ±5% of set point. This includes all VAV terminal control and exhausted BSCs, canopy hoods, ventilated cage racks, necropsy tables, and other scientific equipment with supply or exhaust ventilation
14. For communication interfaces and EMS/ATC control panels:
    a) Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
    b) Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
    c) Check power supplies for proper voltage ranges and loading.
    d) Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
    e) Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
    f) Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
    g) Ensure that all outputs and devices fail to their proper positions/states.
    h) Ensure that buffered and/or volatile information is held through power outage
    i) With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the OI.
    j) Check for adequate grounding of all EMS/ATC panels and devices.
    k) Run self-diagnostic routines and ensure they are functional
    l) Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.

15. Coordinate desired initial alarm strategies with Owner's Operators. Set all required alarms and document the initial settings in the startup documentation
16. Coordinate all initial set points with Owner's Operators. Ensure those set points are active
17. For Operator Interfaces (OIs):
    a) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
    b) Output all specified EMS/ATC reports for review and approval.
    c) Verify that the alarm printing and logging is functional and per requirements.
    d) Verify that trend archiving to disk and provide a sample to the CA for review.
    e) Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
    f) Verify that real time and historical trends are accessible and viewable in graph format.
    g) Verify that paging/dial out alarm annunciation is functional.
    h) Verify the functionality of remote OIs and that a robust connection can be established consistently.
    i) Verify that required third party software applications required with the bid are installed and are functional.
    j) Demonstrate open protocol and custom third-party interfaces reliably communicate and check response time.
    k) Verify response times and screen update and refresh times are per the requirements.
    l) Verify that all custom programs are editable from the OI. Check upload, download, backup and restore capabilities of system configuration information as well as custom programs.
    m) Verify schedules are set up and working.
    n) Verify Owner stipulated security and permissions is set up and functional.
    o) In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.
18. Verify proper interface with fire alarm system.
19. Verify proper interface with control panels of equipment with self-contained controls that are being monitored by the EMS/ATC.

B. Submit Start-Up/Pre-functional Documentation. This shall be completed, submitted, and approved prior to demonstration and Acceptance Phase.

3.02 SENSOR CHECKOUT AND CALIBRATION

A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.

B. Calibration: Calibrate all sensors using one of the following procedures:
    1. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or EMS/ATC) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
    2. Sensors with Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and EMS/ATC control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by

the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or EMS/ATC) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 23 09 00.

3.03 LOOP TUNING

A. For all control loops, contractor shall tune the loops to ensure the fastest stable response without hunting, offset or overshoot with tolerances defined above. Contractor shall introduce upsets to the load when possible to affect response. Otherwise, set points can be changed to affect the response.
B. Generally, tune loops during periods of high gain.
C. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.

3.04 COIL VALVE LEAK CHECK

A. Verify proper close off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the OI, command the valve to close. Energize fans. After 5 minutes observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

3.05 VALVE AND DAMPER STROKE SETUP AND CHECK

A. For all valve and actuator positions checked, verify the actual position against the OI readout.
B. For valves, set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command valve to a few intermediate positions. If actual valve position doesn’t reasonably correspond, replace actuator or add pilot positioner (for pneumatics)
C. For dampers, set AHU to normal operating mode and control. Command damper closed and verify the damper is fully closed against the blade and edge seals. Adjust as required for a tight seal. Command damper open and verify damper is in the fully open position. Command the damper to a few intermediate positions. If actual damper position does not reasonably correspond, replace the actuator.

3.06 ALARM SET POINT COORDINATION

A. The Contractor shall prepare a list of all conceptual point types and recommend the types and recommended alarming strategies and set point for review of Commissioning Agent and Owner. Owner shall use this alarm list to provide direction to Contractor for alarm strategies and set points. Alarm list shall be provided at least two months prior to the first functional test. Contractor shall have alarm set points entered prior to functional testing. Omitting an alarm setting, using the wrong strategy, or entering the wrong set points will be considered a failure from the perspective of the functional test.

3.07 GRAPHIC COORDINATION

A. The Contractor shall prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review of Commissioning Agent and Owner. Owner shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.

3.08 EMS/ATC DEMONSTRATION

A. Demonstrate the operation of the EMS/ATC hardware, software, and all related components and systems to the satisfaction of the Commissioning Agent and Owner. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of additional site visits by the Commissioning Authority for re-demonstration, Contractor shall reimburse Owner for costs of subsequent Commissioning Authority site visits.
B. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.
C. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CA.
D. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
    1. Demonstrate that required software is installed on EMS/ATC workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
    2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
    3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
    4. Demonstrate correct calibration of input/output devices using the same methods specified for the start-Up tests. A maximum of 10 percent of I/O points shall be selected at random by Commissioning Authority and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Commissioning Authority for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
    5. Demonstrate that all EMS/ATC and other software programs exist at respective field panels. The EMS/ATC programming and point database shall be as submitted and approved.
    6. Demonstrate that all EMS/ATC programs accomplish the specified sequences of operation.
    7. Demonstrate that the panels automatically recover from power failures, as specified.
    8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
    9. Identify access to equipment selected by Commissioning Authority. Demonstrate that access is sufficient to perform required maintenance.
    10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
E. EMS/ATC Demonstration shall be completed and approved prior to functional testing.
F. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be re-accomplished.

3.09 FUNCTIONAL PERFORMANCE TESTING

A. Requirements for assistance with functional performance testing are specified in the Section 01 19 15. Provide assistance during Functional Performance Testing per the Section 01 19 15 and related Specifications.

3.10 EMS/ATC ACCEPTANCE PERIOD

A. After approval of the EMS/ATC Demonstration and prior to Substantial Completion, Acceptance Phase shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been started and the startup documented, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, etc.), and TAB report has been submitted and approved. Acceptance Period and its approval will be performed on a system-by-system basis if mutually agreed upon by contractor and Owner.

B. Operational Test: At the beginning of the Acceptance Phase, the system shall operate properly for two weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, contractor shall forward the trend logs to the CA for review. CA shall determine if the system is ready for functional performance testing and document any problems requiring contractor attention.

   1. If the systems are not ready for functional performance testing, Contractor shall correct problems and provide notification to the Owner's representative that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one-week period. This process shall be repeated until Commissioning Authority issues notice that the EMS/ATC is ready for functional performance testing.

C. During the Acceptance Period, the contractor shall maintain a hard copy log of all alarms generated by the EMS/ATC. For each alarm received, contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the contractor's opinion, the cause of the alarm is not the responsibility of the contractor, contractor shall immediately notify the Owner's representative.

D. During the Acceptance Phase, the contractor shall maintain all controller network and workstation hardware and software in a state that will allow remote access by Commissioning Agent to Trend Logs as specified below.

3.11 TREND LOGS

A. This contractor shall configure and analyze all trends required below and under Section 23 09 00.

B. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be interval recordings of system I/O parameters or Change of Value based trends that record when a system value changes by more than a specified threshold.

C. CA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CA.

D. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and field name being the horizontal axis. Data shall be forwarded in one of the following formats.

   1. Microsoft EXCEL Spreadsheet (.xls)
   2. Comma Separated Value (.csv or .txt)

E. Sample times indicated as COV (±) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When outputting to

the trending file, the latest recorded value shall be listed with any given time increment record. If the EMS/ATC does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.

F. Contractor shall provide the CA with required passwords, phone numbers, etc. to allow the CA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.

G. Trending Requirements: At a minimum, trend the following on 10 min. intervals for analog values and change of value for binary values.
   1. Outside Air Temperature
   2. Outside Air Enthalpy
   3. Cooling Tons
   4. All sensed Hydronic Temperatures
   5. All sensed air temperatures on primary equipment
   6. All air flows (with the exception of terminal devices)
   7. All damper outputs on primary equipment
   8. All valve outputs on primary equipment
   9. All sensed Fan Volumes on primary equipment
   10. All inputs and outputs to VFDs
   11. Return (or exhaust) Air Temperature on each air handler
   12. All safety indications
   13. Status on all primary equipment
   14. All air and water pressures on primary equipment or systems
   15. Space Temperatures
   16. Steam Flow
   17. Electricity consumption where monitored.
   18. Natural Gas flows
   19. Converter steam valves and hot water temperatures
   20. Steam supply pressures and temperatures.
   21. Basically, all points on primary equipment and selected sampling of terminal points unless approved otherwise

H. Trending to document functional tests may typically be at a more frequent interval. Consult with the CA to determine the required intervals for functional testing and modify intervals as required.

3.12 TREND GRAPHS

A. Trend graphs shall generally be used during the Acceptance Phase to facilitate and document testing. Prepare controller and workstation software to display graphical format trends during the Acceptance Period. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the functional performance tests.

B. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.

C. Indicate engineering units of the y-axis values; e.g. °F., inches w.g., Btu/lb, percent wide open, etc.

D. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.

E. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.

F. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period.

G. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

3.13 WARRANTY PHASE EMS/ATC OPPOSITE SEASON TRENDING AND TESTING

A. Trending: throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Period. Contractor shall forward archived trend logs to the CA for review upon CA's request. CA will review these and notify contractor of any warranty work required.
B. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CA shall schedule and conduct Opposite Season functional performance testing. Contractor shall support this testing and remedy any deficiencies identified.

3.14 SOFTWARE OPTIMIZATION ASSISTANCE

A. The contractor shall provide the services of a controls technician as specified above at the project site to be at the disposal of the CA. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CA during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8-hour days, unless otherwise mutually agreed upon by contractor, Commissioning Authority, and Owner. The Owner's representative shall notify contractor 2 days in advance of each day of requested assistance.
B. The controls technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the controls technician provided cannot perform every software task requested by the Commissioning Authority in a timely fashion, contractor shall provide additional qualified personnel at the project site as requested by the Commissioning Authority, to meet the total specified requirement.

3.15 EMS/ATC OPERATOR TRAINING

A. Refer to Division 23.

- END OF SECTION 23 08 59 -

SECTION 23 09 00
INSTRUMENTATION AND CONTROL 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 control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Division 23 Section "Meters and Gauges for HVAC Piping" for measuring equipment that relates to this Section.

C. Comply with all code requirements and fire safety requirements.

D. The Automatic Temperature Control System (ATC), and Energy Management System (EMS) shall be electric/electronic actuation direct digit control (DDC), BTL BACnet Certified System and installed in a fully turnkey fashion. The EMS system shall perform all the required functions that the ATC systems cannot, and shall provide the means for the owner to control and monitor all building systems through their existing County wide EMS front end. The ATC/EMS shall be by Johnson Controls (sole source). The ATC system shall integrate all VRV/VRF systems, ACCU's, AHU's, DOAS units, and all equipment into a common controlled and monitored system for integration into the Johnson Controls building automation system. The ATC contractor shall provide all equipment controls except for the VRV/VRF system and Refrigeration controls by the unit manufacturer. The AHU manufacturer shall provide a terminal strip for field mounting all controls provided by the ATC Contractor. Coordinate with the unit manufacturer and include in the bid all devices, sensors and controllers for a fully turnkey installation.

1. General Requirements:

a. The ATC system shall be Direct Digital Control (DDC) system.

1) The controls system shall utilize a single software platform

2) All controllers, both supervisory and unitary (unit controllers) must be programmable.

3) All exterior lights shall operate through a combination of photocell (on) and scheduling (EMS – off) with a manual four (4) hour override available.

4) Interlock the emergency generator, Kitchen refrigerator and freezer and interior lighting controls to the EMS. Monitor the incoming electric service.

2. All software updates available for the ATC system during the warranty period shall be installed and tested to ensure proper operation at no extra cost.

3. All programming language and graphics shall be the same software package and shall remain the property of the owner. The use of more than one software package shall be considered non responsive and will not be accepted.

4. All software and hardware shall be licensed to the Owner.

5. The Owner shall have the ability to be self-sufficient with regards to installation and programming of all software and hardware.

E. Coordinate controls with controlled equipment. Upon completion of the work, calibrate and adjust all controls for proper function. Electric wiring, power to ATC panels, including interlock wiring for equipment such as air handlers, fans, terminal control units, fan coil/blower coil units, VRV/VRF system, split systems, lighting, generator, incoming electrical service, water heaters air curtains, units heaters (all types), pool equipment etc., shall be furnished and installed under this section. The ATC Contractor shall provide transformers, wiring, 120 volt power wiring, power to ATC panels, necessary relays, and controls, etc., not provided under Divisions 26, 27 and 28 for the automation of the ATC/EMS as required by the Sequence of Operation and the Input/Output Schedule. All electrical work shall conform to the applicable requirements of Divisions 26, 27 and 28. All control wiring shall be installed in EMT conduit in accordance with Divisions 26, 27 and 28, except for control wiring to terminal control units located above accessible ceilings, which shall be plenum-rated cable.

F. All automatic temperature control dampers, valves and separable wells for immersion elements furnished by the Control Manufacturer shall be installed by the Mechanical Contractor or his sheetmetal subcontractor under the Control Manufacturer's supervision.

G. Reference is hereby made for this Contractor to become familiar with Division 25, 27 and 28 of these specifications. Familiarization is for coordination purposes only. The Control Contractor shall provide all necessary relays, contacts, interlock wiring, etc., not provided under Division 26, 27, and 28 for the automation of the ATC and EMS Systems as required by the sequence of operation and input/output schedule. The Contractor shall provide all power wiring for all control panels including emergency power for the building system. Coordinate where power can be obtained with the Electrical Contractor. The Control Contractor shall coordinate all requirements with the building Fire Alarm System. The Control Contractor shall provide all additional devices and interlock wiring required for the automation of the ATC System and monitoring of the EMS System.

H. Provide all labor, materials, equipment and services necessary for and incidental to furnishing and installing a complete stand-alone Electric/Electronic/DDC Automatic Temperature Control System to meet the requirements of the sequence of operation. The System Supplier shall assume and execute full responsibility to select, furnish, install, connect, test, calibrate, and place into operation all specified components, assemblies, and accessories needed for a complete and functional system of HVAC monitoring and control in full compliance with the requirements of the specifications.

I. The Control Contractor shall provide control and monitoring system devices and sensors that conform to the standards of NFPA 72D. Devices and sensors shall be provided to suit the function of the Input/Output Point Summary shown on the Contract Drawings.

J. The ATC Contractor shall coordinate with Division 23, Mechanical, and shall furnish and install all items necessary to meet the requirements of the Sequence of Operation and the Energy Management System (EMS) indicated on the drawings and as required in this specification. The ATC System shall be one of Direct Digital Control utilizing electric/electronic actuation.

K. The direct digital control system shall include all necessary and specified control equipment properly installed in accordance with the specifications and drawings and shall include, but not be limited to the automatic temperature control and energy management system of the following:
   1. Air Handling Units including Energy Recovery (DOAS) Units,
   2. Variable Refrigerant Volume/Flow (VRV/VRF) System
   3. Pool dehumidification system
   4. Smoke Dampers/Fire and Smoke Dampers.
   5. Ventilation Systems.
   6. General Exhaust Systems.
   7. Unit Heater/Baseboard Radiation/Convector Control/Radiant Heaters/Cabinets Unit Heaters (all types).
   8. Mechanical/Electrical Room Heat and Ventilation Control.
   9. Terminal Control Units (Fan Coil, etc.)
   10. Kitchen Ventilation Equipment
   11. Miscellaneous Interlock Wiring for Air Curtain Fan Speed Switches, Fan On-Off Switches, Time Delays, Electric Heating Units, Heat Recovery Wheels, Liquid Sensors, Split A/C Units, air-cooled condensing units, Plumbing Equipment, Emergency Generator, Site Lighting Systems, indoor lighting systems, incoming electric service, carbon monoxide sensors, pool systems etc.

L. The ATC Contractor shall provide input/output devices and sensors, conduit system and interlock wiring between sensors and the Energy Management System. The ATC Contractor shall provide input/output devices and sensors, conduit system and interlock wiring between sensors and the Energy Management System. At end of the project these controls must be the latest version. Coordinate all wiring, programming, commissioning, calibration, etc. with the VRV/VRF, DOAS unit, AHU, pool dehumidification unit, Air Cooled Condensing Units etc. with each manufacture for a fully turnkey system. Provide all integration, graphics, trending, alarming, scheduling, etc. for these systems and equipment.

M. EMS:
   1. The Energy Management System (EMS) shall include furnishing and installing of all hardware, software and accessories required to perform the functions listed and as described hereinafter in the Sequence of Operations.
   2. The Contractor shall provide the Energy Management System to enable the expansion of the system to include the monitoring and control of the items indicated in the control point schedule (I/O Summary) and listed in these Contract Documents and Specifications and existing equipment.
   3. The Contractor shall provide programming to incorporate the new points into the data file.
   4. Provide a CPU for the facility.
   5. The entire system shall be capable of being monitored and controlled via a smart phone.

N. The project will require a minimum of a CPU, network control unit(s), central plant controller(s), etc and all auxiliary devices required for a complete system as per specified Sequence of Operation. The ATC Contractor will not be relieved of any responsibility or requirements necessary for a complete and operational ATC System. The ATC System shall be an all-electric/electronic actuation, direct digitally controlled. Coordinate all control requirements with the equipment manufacturers for a fully turnkey system. Extend EMS Interface Communication line and provide all necessary devices, software, etc., for remote control and monitoring from the EMS. The EMS shall include all hardware, software, and programming to graphically display the building, equipment and system.

O. The building shall be provided with stand-alone local controls. The Energy Management System shall override local controls when "Local-Remote" System switches are in the remote position. Position of all "Local-Remote" switches shall be monitored by the Energy Management System. If failure of the Energy Management System occurs when the "Local-Remote" System

switch is indexed to remote control, all controls functions shall revert back to local controls. Reset to remote controls shall be manual.

P. Each DDC controller shall communicate over a BACnet communications bus installed between the controllers by the ATC subcontractor. A communications master control panel shall be provided by the ATC subcontractor. This panel shall:

1. Provide the Owners personnel with a convenient location to obtain system information using a hand-held (iPad or Microsoft Surface Pro 4) terminal. The hand-held terminal shall be available from more than one manufacturer as a standard product. The Owner shall have access to the system to view space temperatures and schedules for remote control and monitoring purposes.

2. Collect ATC information and transmit it to the main ATC panel.

3. Receive energy management directions from the main ATC panel.

Q. Within 10 working days of Contract Award a meeting shall be scheduled with the Engineer, the Construction Manager, Mechanical Contractor, the Controls Contractor the Equipment Manufacturer, and the Owner. The purpose of the meeting will be to develop the sequences, points lists, and interfaces necessary to reduce the number of issues.

R. All controllers, sensors, and switches shall be hard-wired. All connections between the main ATC panel and sub-panels/controllers shall be hard-wired. Wiring shall be installed in accordance with Building and Electrical codes as well as any other applicable codes.

S. All equipment shall have a RIB switch relay override for service and troubleshooting. Install RIB within three feet of the starter, VFD, or motor rated switch of the equipment being controlled.

T. Sensors, not thermostats, shall be used to read temperature in spaces and shall have a range of 0° F to 120°F.

U. All equipment shall be controlled by a stand-alone DDC controller. These controllers shall be provided and field installed by the ATC Contractor. The ATC system shall only enable these pieces of equipment which are expected to run “stand-alone”. Factory controllers will not be acceptable.

V. The data transmitted from the ATC system to the Command Center shall include the following, as a minimum:

1. Equipment Information:
   a) Start/Stop signals for all equipment
   b) Summer/Winter single point switch-over capability
   c) Adjustable reset schedules

2. General Information:
   a) Outside Air Temperature
   b) Alarm Data

3. Zone Information:

   a) All true Fan Status (On/Off/Speed) –
      - Read differential pressure for water
      - Read status and safeties for air
   b) Zone Temperature as measured by Zone Sensor

c) Override Status
d) Alarm Data (i.e. readings outside of normal system parameters)
   o Temperature ± 10° from set point for ½ hour
e) CO_2 Level of Zones
f) Discharge and Return Air Temperature for Zones with constant volume and variable volume Air Handling Units.
g) Equipment Status (Default/Open/Off)

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. MS/TP: Master slave/token passing.

D. PC: Personal computer.

E. PID: Proportional plus integral plus derivative.

F. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within minimum tolerances as follows, unless stricter tolerances are specified for specific devices hereinafter:

   a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
   e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
   f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
   g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
   h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
   i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
l. Airflow (Terminal): Plus or minus 10 percent of full scale.
m. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
n. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
o. Carbon Monoxide: Plus or minus 5 percent of reading.
p. Carbon Dioxide: Plus or minus 50 ppm.
q. Electrical: Plus or minus 5 percent of reading.

1.5 SEQUENCE OF OPERATION

A. Refer to Drawings for Sequence of Operation.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. LEED Submittals: Comply with Section 018113.

1. EQ Credit 1: Enhanced indoor air quality strategies.
   a. For wall mounted carbon dioxide sensors, documentation indicating accuracy in percent.

C. 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. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:

   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.

c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:

    a. Schematic and logic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.
    e. Control Systems Network Architecture and Riser Diagram, including all nodes, devices, interfaces, and interconnections.
11. Data Sheets of all products.
12. Points Lists for all physical and virtual (software) points to be provided at minimum, including for each point the tag, type, range, unit's descriptor, address, project specific attributes, and the like.
13. Include in the Points List details of the physical terminations and interconnections for each end device on the networks, including the associated Node, cable terminations, termination location and referenced sequences, special functions to be applied and cross-referenced drawings. All field wiring tags shall be cross-referenced between drawings.
14. Information specifically required by Authorities Having Jurisdiction.
15. Details of the training to be provided, including outlines for each session.
16. Details of the commissioning sheets and procedures proposed.
17. Details of ISP, and associated requirements to be provided by the Owner, at its cost, in order for the contractor to complete the work.
18. Final graphic floor plan with final room numbers.
19. All owner's Standard acronyms.

D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with BACnet (BTL Certified).

E. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.

F. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

G. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

H. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

I. Qualification Data: For Installer and manufacturer.

J. Field quality-control test reports.

K. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project. The Manufacturer shall be Johnson Controls, Inc. (Sole 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 ASHRAE 135 for DDC system components.

D. Supplier shall have an in-place support facility with technical staff, spare parts inventory, and all necessary test and diagnostic equipment.

E. The systems shall be complete in all respects and shall be installed by skilled personnel. The Control Contractor shall have a successful history in the installation and maintenance of automatic temperature control systems similar in size and performance to that specified herein.

F. All electrical wiring in connection with the Automatic Temperature Control System shall be furnished and installed by the ATC Contractor. This shall include all interlock wiring between fans, pumps, heating and cooling systems, heaters, terminal control units, etc.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update the EMS to latest version of software at Project completion. Provide software updates for five (5) years after substantial completion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system and with building master clock.

C. Coordinate equipment with Division 28 Section "Access Control" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 27 Section "Clock Systems" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Division 28 Section "PLC Electronic Detention Monitoring and Control Systems" to achieve compatibility with equipment that interfaces with that system.

F. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

G. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

H. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

I. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

J. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

K. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

L. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.10 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. Software: Provide back/recovery disk for all software.

1.11 WORK BY OTHERS

A. Automatic Temperature Control valves and separable wells for immersion elements furnished by the control manufacturer shall be installed by the Mechanical Contractor under the Manufacturer’s supervision. The Control Contractor shall deliver to the Mechanical Contractor valves and wells for installation within the various systems.

B. All automatic dampers furnished by the control manufacturer shall be installed by the Mechanical Contractor under the control manufacturer’s supervision.

1.12 GUARANTEE:

A. The control system including all components, system software, parts and assemblies herein specified shall be free from defects in workmanship and materials under normal use and service. After completion of the installation, the Control Manufacturer shall regulate and adjust all thermostats, control valves, control motors, and other equipment provided under this contract. Additionally the Contractor shall complete a comprehensive test as witnessed by the Owners Representative and Engineer to evaluate system operation. This shall include six (6) month follow ups throughout the warranty period. All software updates shall be provided during the two (2) year warranty period. If, within two (2) years from the date of substantial completion, any of the equipment herein described is proved to be defective in workmanship or materials, it will be replaced or repaired at no additional cost to the Owner. The Control Manufacturer shall, after completion, provide any service incidental to the proper performance of the Control System under guarantees outlined above for a period of two (2) years. Normal maintenance of the system is not to be considered part of the guarantee. All corrective modifications made during warranty service periods shall be updated on all user documentation including "as-built" shop drawings and on user and manufacturer archived software disks.

B. The Control Contractor shall completely check out, calibrate and test all connected hardware to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

C. Upon completion of the work, the control drawing (Electronic Drawing format printed in color) encased in heavy plastic shall be provided in each mechanical equipment space. Layout shall show all control equipment and the function of each item indicated. All Electronic format Control Drawings shall be archived on a CD/DVD and turned over to the Owner.

D. Upon completion of the work, the Control Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the control system for a period of not less than five (5) eight (8) hour days. All training shall be by the Control Contractor shall be on site and shall utilize specified manuals and as-built documentation. In addition to the start-up instructional period the ATC Contractor shall provide one (1) eight hour instructional period 6 months after the initial instructions and one (1) eight hour instructional period 12 months after the initial instructions (i.e., one during cooling season/one during the heating season). Provide vouchers for additional Owner training.

1.13 TRAINING

A. The Controls Contractor shall provide the following training services:

1. 2 Days (16 hours) Onsite
   - 1 Period (8 hours) onsite to include but not limited to showing where new controls are located. <u>Agenda is required</u>.
   - 1 Period (8 hours) on site.
     - (4) hours 12:00 pm – 4:00 pm
       - 12:00 pm – 2:00 pm Graphics and n avigation for day time personal
       - 2:00 pm – 4:00 pm Navigation and Schedules for night time personal
     - (4) hours 12:00 pm – 4:00 pm (One week after first (4) hours)
       - Review any required changes from first (4) hours
       - Any other concerns

2. 2 Days Offsite Factory Training
   - Provide vouchers for classes to be used at the discretion of the Owner.

- o Round-trip travel expenses to fly from Baltimore to the training destination, lodging and car rental expenses for the entire duration of the course shall be paid by contractor if the location of the site where the course is offered is other than the Baltimore/Washington area or 150 miles round-trip

OR

(1) Three day training class for up to 3 people to be held at the site. ALL materials and training stations to be provided by the instructing contractor. Certified instructor required. Certificates of completion to be provided at conclusion of class. Lunch is to be provided by instructing contractor.

1.14 GRAPHICS

A. All proposed graphics shall be provided to the Owner as submittals for review and approval prior to installation.

B. The home screen shall include links to the Mechanical and Controls drawings and Balancing Reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 DDC EQUIPMENT

A. Provide hand held iPad Pro and/or Microsoft Surface Pro 4 Tablet.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
   d. Software applications, scheduling, and alarm processing.
   e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

   a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
   b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
   c. Chiller Control Programs: Control function of chilled-water reset and equipment sequencing.
   d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
   e. Remote communications.
   f. Maintenance management.
   g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).
4. Enclosure: Waterproof rated for operation at 40 to 150 deg F (5 to 65 deg C).

2.5 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, NEMA 1, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide

common keying for all panels. Provide means of storing control system instructions and drawings inside cabinet for future reference. Provide UL listed cabinets for use with line voltage devices.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.
2. Acknowledge Switch: Horn is silent and indicating light is steady.
3. Second Alarm: Horn sounds and indicating light is steady.
4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.6 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

2.7 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Available Manufacturers:

a. Johnson Controls, Inc.
b. Honeywell
c. Or equal.

2. Accuracy: Plus or minus 0.5 deg F (0.3 deg C) at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: 18 inches (460 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
5. Averaging Elements in Ducts: 72 inches (1830 mm) long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).

6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Setpoint adjustment: Exposed.Set-Point Indication: Concealed.
   b. Override Button:
   c. Display: LED.
   d. Color: Standard Manufacturer's Color.
   e. Orientation: Vertical."

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws. Provide for Gymnasium and/or auxiliary gym spaces and room security areas.

C. RTDs and Transmitters:

1. Available Manufacturers:

   a. Johnson Controls, Inc.
   b. Honeywell.
   c. Or equal.

2. Accuracy: Plus or minus 0.2 percent at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, 18 inches (460 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
5. Averaging Elements in Ducts: 24 feet (7.3 m) long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (0.84 sq. m); length as required.
6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

   a. Set-Point Adjustment: Concealed.
   b. Set-Point Indication: Concealed.
   c. Thermometer: Concealed.
   d. Color: Manufacturer's Standard Color.
   e. Orientation: Vertical.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws. Provide for gym, and where indicated on the Drawings.

D. Smart Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:
   a. Vaisala – Sole Source for Dewpoint Sensors and acceptable for space and duct humidity sensors.
   b. Vaisala or Veris – For space and duct humidity sensors.
   c. Provide sensors by the VRF and/or AHU manufacturer where required by the unit manufacturer to be compatible with their control system.

2. Accuracy: 2 percent full range with linear output.
3. Room Sensor Range: 20 to 80 percent relative humidity. Vaisala Model Humicap H Sensor.

4. Room Sensor Cover Construction: Manufacturer's standard locking covers.

   a. Set-Point Adjustment: Concealed.
   b. Set-Point Indication: Concealed.
   c. Thermometer: Concealed.
   d. Color: Manufacturer's Standard Color.
   e. Orientation: Vertical.

5. Outside-Air Sensor: 0 to 100 percent relative humidity range with mounting enclosure, (Radiation Shield Vaisala Model 2212HM) suitable for operation at outdoor temperatures of minus 22 to plus 185 deg F (minus 30 to plus 85 deg C). Provide PPS grid with stainless steel netting to protect sensor. Provide electric heater option.
6. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity. Vaisala Model HMP 233.

E. Pressure Transmitters/Transducers:

1. Available Manufacturers:

   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. Vaisala.
   e. Rosemount.
   f. Air Monitor, Inc.
   g. Ebtron, Inc.
   h. United Electric.
   i. Ashcroft.
   j. Veris.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: -0.25 to 0.25-inch wg (0 to 62 Pa).
   d. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).
      Duct Static Pressure Traverse Probes. Provide where indicated duct static traverse probe capable of continuously monitoring the duct or system static pressure it serves. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Said sensors shall not protrude beyond the surface of the probe. The duct static traverse probe shall be of extruded aluminum construction and (except for 3/4" diameter probes with lengths of 24" or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure, without need for correction factors, with an instrument accuracy of 0.5%^. The duct static pressure traverse probe shall be the STAT-Probe/1 as manufactured by the Air Monitor Corporation or Gold Series by Ebtron.
   e. Electronic Velocity Pressure Transmitters. The electronic differential pressure/flow transmitters shall be of industrial process control quality with operating features described herein and capable of producing the outlined performances. The transmitter shall be capable of converting signals of static or differential pressure into a 4-20 mADC output signal linear to the sensed pressure. By means of an integral, user-selectable, square root extractor, the transmitter shall be capable of converting the total and static pressure signals for a flow element into a 4-20

mADC output signal linear to airflow velocity or volume, the transmitter shall be furnished with a built-in 3-way zeroing valve. The transmitter shall be furnished within an aluminum NEMA 1 enclosure with external connection terminals for field wiring. The operating span of the transmitter shall have the capability of factory or field calibration down to 40% of its natural span and the transmitter shall meet or exceed the following performance and application criteria.

Square Root Extractor:	Integral - User-selectable.
Zeroing:	Integral - Manual with 3-way switch.
	(7) Natural Spans, from 0 - .10 IN w.c. to 0-10.0 IN w.c. (7) Bi-Polar Spans
Accuracy:	+/-0.5% of Natural Span, including non-linearity, hysteresis, and non-repeatability.
Temperature Effect:	Zero: 0.015% of Natural Span / EF.
Span:	0.015% of Natural Span / EF.
Power Supply:	14-40VDC
Power Consumption:	0.5 Watts at 24 VDC
Output Signal:	4-20mADC, 2-wire configuration.
Overpressure Limit:	25 psig.

f. The transmitter shall be the VELTRON DPS 2500 as manufactured by Air Monitor Corporation, or Gold Series by Ebtron or equal product by Ashcroft.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential – United Electric H105K.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

F. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Concealed.
2. Set-Point Indication: Concealed.
3. Thermometer: Concealed or without adjustment and readout.
4. Color: Architect shall select.
5. Orientation: Vertical.

G. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.
2. Guards: Locking, solid metal, ventilated.
3. Adjusting Key: As required for calibration and cover screws.

H. Static Pressure Sensors.

1. Shielded Room Space Static Pressure Sensor: Provide for each room or space, a shielded static pressure sensor suitable for wall or ceiling surface flush-mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 3/8" FPT takeoff fitting, all contained in a 10 gauge aluminum welded casing, with brush finish on exposed surfaces. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 fpm from a radial source. The shielded room or space static pressure sensors shall be the S.A.P./ 3 Shielded Static Air Probes as manufactured by Air Monitor Corporation, or as approved equal.
2. Shielded Plenum Static Pressure Sensor: Provide where indicated for each plenum two shielded static pressure sensors suitable for mounting externally on the plenum wall in opposing positions. The plenum pressure sensors shall be complete with multiple

sensing ports, pressure impulse suppression chamber, airflow shielding, and 3/8" compression elbow takeoff fitting, all contained in a 10 gauge steel welded casing. With polyurethane paint finish on exposed surfaces. These probes shall be capable of sensing the static pressure of the plenum or duct in the proximity of the sensor to within 1% of the actual pressure value. The shielded plenum static pressure sensors shall be the S.A.P./4 Shielded Static Air Probe, as manufactured by Air Monitor Corporation, Santa Rosa, California.

3. Outdoor Static Pressure Sensor: Provide for the room or space static pressure indicating or controlling systems an outdoor static pressure sensor constructed of 10 gauge anodized aluminum with a 2" diameter FPT connection. The outdoor air probe shall be capable of sensing the outside atmospheric air pressure to within 2% of the actual value when subject to radial wind velocities up to 80 miles per hour with approach angles up to 30 degrees to the horizontal. Locate where recommended by the Manufacturer. The Static Outside Air Problem shall be the S.O.A.P., as manufactured by Air Monitor Corporation, or as approved equal.
4. Duct Static Pressure Traverse Probe: Provide where indicated, duct static traverse probes capable of continuously monitoring the duct or system static pressure it serves. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Said sensors shall not protrude beyond the surface of the probe. The duct static traverse probes shall be of extruded aluminum construction and (except for 3/4” diameter probes with lengths of 24” or less) shall be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probes shall be capable of producing a steady, non-pulsating signal of standard static pressure, without need for correction factors, with an instrument accuracy of 1%. The duct static pressure traverse probes shall be the STAT-probe as manufactured by Air Monitor Corporation, or Ebtron.

2.8 STATUS SENSORS

A. Status Inputs for Fans: Split-core current switches, capable of providing repeatable status at part load on VFD driven motors.

B. Status Inputs for Pumps: Split-core current switches, capable of providing repeatable status at part load on VFD driven motors.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Available Manufacturers:

a. BEC Controls Corporation.
b. I.T.M. Instruments Inc.
c. McDonald Miller.
d. Johnson Controls.
e. Penn Controls.

2.9 GAS DETECTION EQUIPMENT

A. Available Manufacturers:

1. B. W. Technologies.
2. CEA Instruments, Inc.
3. Ebtron, Inc.
4. Gems Sensors Inc.
5. Greystone Energy Systems Inc.
6. Honeywell International Inc.; Home & Building Control.
7. INTEC Controls, Inc.
8. I.T.M. Instruments Inc.
9. MSA Canada Inc.
10. QEL/Quatrosense Environmental Limited.
11. Sauter Controls Corporation.
12. Sensidyne, Inc.
13. TSI Incorporated.
14. Vaisala.
15. Vulcain Inc.

B. Carbon Monoxide Detectors: Provide in boiler and water heater rooms and adjacent to the first diffuser served by fuel fired equipment and in supply air ducts connected to fuel fired furnaces (AP-C SL-701 or equal). Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F (0 to 40 deg C); with 2 factory-calibrated alarm levels at 50 and 100 or 35 and 200 ppm.

C. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting. Measurement range shall be 0-2000 ppm, accuracy shall be 20 ppm, repeatability shall be +/- 1% full scale, long term stability shall be 5% over 5 years and response time shall be less than 60 seconds. Vaisala Carbocap GMD/W Series or equal of Veris.

D. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F (0 to 593 deg C) and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

E. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.10 FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station. Locations shall be determined on site with the Manufacturer's Representative, Owner, Engineer and Commissioning Agent. Additionally the Manufacturer's Representative shall be on site during the time of installation.

1. Available Manufacturers:

   a. Air Monitor Corporation.

   b. Ebtron, Inc.

2. Casing: Galvanized-steel frame.
3. Flow Straightener: Aluminum honeycomb, 3/4-inch (20-mm) parallel cell, 3 inches (75 mm) deep.
4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.
5. Duct-Mounted: Provide where indicated, air flow measuring stations with air straighteners capable of continuously monitoring the fan or duct capacities (air volumes) they serve. Each airflow measuring station shall contain multiple total and static pressure sensors positioned at the center of equal area of the station cross-section and interconnected by their respective averaging manifolds. For stations of 4 square feet or less, one total and one static pressure sensor shall be present for every 16 square inches of station area respectively. For stations of larger area, one total and one static pressure sensor shall be present for every 36 square inches of station area respectively. The airflow measuring station shall be fabricated of a minimum of 14 gauge galvanized steel, welded casing in 8" depth with 90 degree connecting flanges in a configuration and size equal to that of the duct it is to be mounted into. Each station shall be complete with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to the casing, total and static pressure sensors located on an equal area basis and connected to symmetrical averaging manifolds, internal piping, and external pressure transmitter ports. An identification label shall be placed on each station casing listing model number, size, area, and specified airflow capacity. The maximum allowable pressure loss through the station shall not exceed .015" wc at 1000 fpm, or .085" wc at 2000 fpm. Each station shall be capable of measuring the airflow rate within an accuracy of 2 percent as determined by U.S.G.S.A. Certification Tests. The stations shall have a self-generated sound rating of less than NC 40, and the sound level within the duct shall not be amplified, nor shall additional sound be generated. The airflow measuring stations shall be the Fan-Evaluator or Duct Air Monitor Device as manufactured by Air Monitor Corporation, or as approved equal of Ebtron.
6. Outdoor Air Flow Station: The outdoor air flow station shall be Air Monitor, Inc. VOLU-FLO/OAM. Locate airflow measuring device upstream of the outside air damper in accordance with the manufacturer's installation requirements. Provide appropriate mounting brackets and expanded metal grid.

2.11 THERMOSTATS

A. Available Manufacturers:

1. Johnson Controls, Inc.
2. Honeywell.

B. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF"; "FAN HIGH-LOW-OFF"; or "FAN HIGH-MED-LOW-OFF".
2. Mount on single electric switch box.

C. Electric, solid-state, microcomputer-based room thermostat with remote sensor.

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set up for four separate temperatures per day.
4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
5. Short-cycle protection.
6. Programming based on weekday, Saturday, and Sunday or every day of week.
7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
8. Battery replacement without program loss.
9. Thermostat display features include the following:

    a. Time of day.
    b. Actual room temperature.
    c. Programmed temperature.
    d. Programmed time.
    e. Duration of timed override.
    f. Day of week.
    g. System mode indications include "heating," "off," "fan auto," and "fan on."

D. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.

E. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

F. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

G. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature, and the following:

1. Reset: Manual.
2. Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.

H. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

I. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet (6 m).
2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.

J. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-automatic- reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet (6 m).
2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.

K. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig (172 kPa), and cast housing with position indicator and adjusting knob.

2.12 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

   a. Belimo Aircontrols (USA), Inc.
   b. Johnson Controls, Inc.
   c. Honeywell.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:

   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
   c. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
   d. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C).
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
12. Run Time: 30 seconds.

2.13 DAMPERS

A. Available Manufacturers:

   1. Air Balance Inc.
   2. American Warming and Ventilating
   3. Ruskin, Inc.
   4. Johnson Controls
   5. Honeywell

B. Dampers: AMCA-rated, Class I, parallel-blade (two-position type) and opposed-blade (proportional control type) design; airfoil shaped double skin construction of 14 gauge equivalent thickness, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 6 inches and length of 48 inches. Provide spring returns for all dampers. Dampers shall be Ruskin Type CD60, or equal of American Warming and Ventilating or Air Balancing, Inc. Round dampers shall be Ruskin Type CER 325.

   1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.

2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
3. Edge Seals, Ultra-Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.14 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

B. All wiring shall be installed in a designated EMT conduit raceway unless otherwise specified. All junction boxes shall have covers painted “Safety Green” and be rigid steel. Minimum size conduit shall be 3/4”.

C. Where it is not possible to conceal raceways in finished locations (i.e., existing masonry walls), surface raceway (wiremold) may be used as approved by the Architect.

D. Individual conductors shall be color-coded and in addition, shall be numbered in the field to identify the particular terminal to which it is attached. Field numbering shall be performed with Brady Markers wrapped around the wire near the terminal connection. All wires shall be terminated with pressure type connectors suitable for wire size, material, and terminal connection.

2.15 DUCT SMOKE DETECTORS

A. Duct Smoke Detectors shall be provided in all air handling supply and return air systems with an air flow of 2000 cfm or greater and in return air systems for each floor in accordance with NFPA requirements and as indicated on the drawings. They shall be designed to provide detection of combustion gases and fire and smoke in air conditioning and ventilating duct systems in compliance with the National Fire Protection Association and Underwriters Laboratories, Inc. Standard UL 167. Duct smoke detectors shall be furnished by the Electrical Contractor and installed by the Mechanical Contractor. The Mechanical Contractor shall provide all interlock wiring to smoke dampers and/or AHU shutdown. The Electrical Contractor shall provide all interlock wiring to the Fire Alarm System and all power wiring. Coordinate duct smoke detector types, quantity of contacts, etc., so as to interface directly with the fire alarm system. Coordinate requirements with Divisions 26, 27, and 28.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. The Automatic Temperature Control System shall be designed, installed, and commissioned in a fully turnkey, fully implemented and fully operational manner.

D. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above the floor.

   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install guards on thermostats in the following locations:

   1. Entrances.
   2. Public areas.
   3. Where indicated.

F. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

I. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

J. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping."

K. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

L. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

M. Duct smoke detectors shall be furnished by the Electrical Contractor and installed by the Mechanical Contractor. The mechanical Contractor shall provide all interlock wiring to smoke dampers and/or AHU shutdown. The Electrical Contractor shall provide all interlock wiring to the fire alarm system and associated power wiring.

N. All safety controls shall be hard-wired so as to be functional in the hand/manual or automatic mode.

O. The ATC Contractor shall be responsible to provide all power to ATC panels, controllers and devices. Provide emergency power to all heating plant control systems. Coordinate obtaining power for ATC Systems with the Electrical Contractor. A few circuits, not all, have been identified for ATC use.

P. Provide liquid level sensors in all condensate drain pans of air handling equipment (AHU's, VRF Indoor FCU's, etc.), elevator pits and where indicated on the drawings. Liquid levels sensors

shall automatically de-energize associated HVAC fan and all liquid level sensors shall alarm when their setpoints are reached through the EMS.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."

1. Install cable in rigid conduit in all mechanical equipment rooms.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway except where above accessible ceilings.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
8. All conduits and raceways shall be installed level, plumb, at right angles to the building lines, and shall follow the contours of the building line.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

F. All Wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent restriction to devices and terminals.

G. The Control Contractor shall be responsible for all electrical installation required for a fully functional control and automation system and not shown on the electrical plans or required by the electrical specifications. All wiring shall be in accordance to all local and national codes.

1. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications.
2. All electric and electronic wiring shall be #18 AWG minimum THHN and shielded if required.
3. All wiring in the central control room shall be concealed in an approved manner.

H. Control Systems Wiring:

1. All conduit raceways, wiring, accessories and wiring connections required for the installation of the Controls Systems shall be provided by the Controls Contractor. All wiring shall comply with the requirements of applicable portions of the Electrical Trade work and all local and national electric codes and the requirements of the AHJ. Low voltage wiring above accessible ceilings shall be plenum rated cable.

2. All Controls Systems wiring materials and installation methods shall comply with the original equipment manufacturer recommendations and standards.
3. The sizing type and provision of cable, conduit, cable trays and raceways shall be the design responsibility of the Controls Contractor.
4. Class 2 Wiring
   a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
   b. Conduit is not required for Class 2 wiring in concealed accessible ceiling locations. Class 2 wiring not installed in conduit shall be supported every 5ft. from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines.
5. Class 2 signal wiring and 24VAC power may be run in the same conduit. Power wiring 120VAC and greater shall not share the same conduit with Class 2 signal wiring.
6. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
   a. All circuits are continuous and free from short circuits and grounds.
   b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
   c. All circuits are free from induced voltages.
7. Provide complete testing for all cables and wiring. Provide all equipment, tools, and personnel as necessary to conduct these tests.
8. Provide for complete grounding of all signal and communication cables, panels and equipment so as to ensure integrity of Controls Systems operation. Ground cabling and conduit at panel terminations. Do not create ground loops

I. Line Voltage Power Sources
1. 120 -volt AC circuits for the Controls Systems shall be taken by the Controls Contractor from electrical trade panelboards and circuit breakers. Coordinate locations with the Electrical Contractor.
2. Circuits used for the Controls Systems shall be dedicated to these Controls Systems and shall not be used for any other services.
3. Controls DDC terminal unit controllers may use 120-volt AC power from motor power circuits.

J. Controls Systems Raceways
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in the Specification. Minimum conduit size 3/4”.
2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the supporting surface.
4. UL//ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls and for final connection to equipment.

K. Penetrations:
1. Firestopping for all penetrations used by dedicated Controls Systems conduits and raceways shall be by the ATC Contractor.
2. All openings in fire proofed or fire stopped components shall be closed by the ATC Contractor using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls, shall be in sleeves, conduit or enclosed raceway.
4. No penetrations through building structural elements, slabs, ceilings and walls shall be made before receipt of written approval from the Architect.

L. Controls Systems Identification Standards:

1. Node Identification: All nodes shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the node environmental location.
2. Cable shall be labeled at every termination with cross-referencing to record documentation.
3. Raceway Identification: Exposed covers to junction and pull boxes of the FMS raceways shall be identified at primary points.
4. Wire Identification: All low and line voltage wiring shall be identified by a number, as referenced to the associated shop and record drawing, at each termination.
5. Wires and cabling shall not be spliced between terminations. Cable shields shall be single end grounded – typically at the panel end outside the panel.
6. Suggested color coding, for use at the Contractors option, are:
   a. Analog Input Cable Yellow
   b. Analog Output Cable Tan
   c. Binary Input Cable Orange
   d. Binary Output Cable Violet
   e. 24 VAC Cable Gray
   f. General Purpose Cable Natural
   g. Tier 1 Comm Cable Purple
   h. Other Tier Comm Cable Blue

M. Field Panel and Device Installations and Locations:
1. The Controls Systems panels, enclosures and cabinets shall be located as coordinated with the Architect at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. All field devices shall be installed per the manufacturer recommendation and in accessible locations as coordinated with the Architect.
3. Panels to be located in damp areas or areas subject to condensation shall be mounted with wall standoffs.
4. Conduit configurations entering or leaving panels and devices shall be such as to preclude condensation traps.

N. Controls Specific Installation Requirements
1. The Mechanical Trade Contractor shall install all in-line mechanical devices including temperature wells, pressure taps, duct smoke detectors, airflow stations, etc.
2. Controls DDC terminal unit controllers may use 120-volt AC power from motor power circuits.
3. The Mechanical Contractor shall install all in-line devices including control valves, dampers, etc.
4. Input flow measuring devices shall be installed in compliance with ASME Guidelines.
5. Outside Air Sensors:
   a. Sensors shall be mounted on a wall selected to minimize solar radiant heat impact or be located in a continuous intake flow adequate to monitor outside air conditions accurately.
   b. Sensors shall be installed with a rain shield and perforated cover.
6. Medium to High Differential Water Pressure Applications (Over 21" wg): Air bleed units, bypass valves and compression fittings shall be provided.
7. Differential Air Pressure Applications (-1" to +1" wg):
   a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
   b. The interior tip shall be inconspicuous and located as shown on the drawings.
8. Air Flow Measuring Station:
   a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
   b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

9. Duct Temperature Sensors:
   a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
   b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
   c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists, such as a mixed air plenum, utilize an averaging sensor.
   d. The sensor shall be mounted to suitable supports using factory approved element holders.
10. Low Temperature Limit Switches:
   a. Install on the discharge side of the first water or steam coil in the air stream.
   b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
   c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
11. Air Differential Pressure Status Switches: Install with static pressure tips, tubing, fittings and air filter.
12. Water Differential Pressure Status Switches: Install with shut off valves for isolation.
13. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke.
14. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
15. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
16. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Controls Systems is to be connected to an external control system as an input (such as chiller control panel), or it is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between building systems. Provide optical isolation between building systems.

3.4 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.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.
8. Provide complete testing for all cables and wiring. Provide all equipment, tools and personnel as necessary to conduct these tests.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: Within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to twelve (12) visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

B. Schedule instruction with Owner. Provide at least a 7-day notice to the Contractor and Engineer of training date. All Operation and Maintenance Manuals shall be provided to Owner three (3) weeks prior to training. Contractor shall be responsible for all operation and maintenance until Owner has had training.

C. Owner’s Instructions: Provide services of manufacturer’s technical representative to completely instruct Owner in all aspects of system maintenance and operation; or a minimum of five (5) 8-hour days to instruct Owner’s personnel in operation and maintenance of electric control system. The ATC Contractor shall submit a functional test check list including all points and sequence of operation points to be reviewed and verified during the Owner Instruction Period. All sequences shall be tested for all air handling systems, VRV/VRF systems, and 100% of all terminal units (terminal heating units, fan coil/blower coil units, VAV control unit(s), etc., for each air handling unit zone. The check list shall include columns for “satisfactory”, “unsatisfactory”, and “comments” for each line item. The check list shall be submitted and reviewed as a shop drawing prior to the instructional period. The Contractor shall include all the check lists in a 3-ring binder (10 copies/sets minimum) for the representatives for the instructional procedure.

D. Demonstrate to the Owners all systems and equipment are functioning properly and performing as designed.

E. Demonstration is not training. Refer to Training in this Section and Section 230500 for additional information.

3.7 LOCAL CONTROL AND EMS CONTROL:

A. For each air handling unit system, each terminal control unit, and as required in the I/O Summary as indicated on the drawings, provide a panel-mounted Hand-Off-Automatic Switch, “Local Control” – “EMS Control” – “Off” switch that allows for the Ems or local controls to start-stop systems and/or equipment.

B. Each system shall operate automatically as described in the sequence of operations when locally controlled; i.e., in the hand position and/or when loss of communications of the remote EMS occurs.

C. Refer to Drawings for additional information.

D. Johnson Controls shall coordinate all controls with the equipment manufacturer, VRV/VRF system, and the associated integration of the controls/control system provided by these manufacturers for a fully turnkey, coordinated, and integrated installation, including all graphics. This coordination shall take place at the time of bidding. A preliminary submittal conference is required prior to reviewing the ATC and associated equipment shop drawings.

3.8 VERIFICATION

A. Fully test and verify all aspects of the Controls Systems Contract work on a point/system/integrated operational basis for all points, features and functions specified.

B. Acceptance Check Sheet
   1. Prepare a check sheet that includes all pints and functions of the Work.
   2. Submit the check sheet to the Architect for approval 60 days prior to testing.
   3. Complete the check sheets for all items and functions of the work. Initial each entry with time/date as record of having fully calibrated and tested the Work. Submit to the Architect as record.
   4. The Architect will use the check sheets as the basis for Acceptance Testing with the Controls Systems Contractor.

C. Provide all necessary specialist labor, materials and tools to demonstrate to the Architect that the Controls Systems have been verified and are operating in compliance with the Controls Systems Contract. Prepare a list of noted deficiencies signed by both the Architect and the Controls Contractor.

D. Contractor shall submit a functional test check list including all points and sequence of operation points to be reviewed and verified during the Owner Instruction Period. All sequences shall be tested for all systems and equipment. The check list shall include columns for SATISFACTORY, UNSATISFACTORY, and COMMENTS for each line item. The check list shall be submitted and reviewed as a shop drawing prior to the instructional period. The Contractor shall include all the check lists in 3-ring binder (10 copies/sets minimum) for the representatives for the instructional procedure.

E. Promptly rectify all listed deficiencies and submit in writing to the Architect a signed report that this has been done.

F. The Architect will retest the deficiencies in conjunction with the controls Contractor at the Architect’s option.

3.9 DATA CONTROL:

A. The following P & ID's show the hardware devices required to be connected to the remote electronic panels, and the standard control software modules to be implemented. In addition, all additional software required to accomplish the detailed sequence of operations specified within this section shall be provided. The following pages also include pseudo points required to be provided for display in logical groups and graphics. Commandable pseudo points shall be commandable directly from all displays.

B. Each analog point shall have unique remote panel resident dual high and dual low limit alarm thresholds as specified elsewhere set in engineering units. Where specified, floating (a band above and below a set point) alarm limits shall be provided.

C. Each digital output shall have a software-associated monitored input. Any time the monitored input does not track its associated command output within a programmable time interval, a "command failed" alarm shall be reported.

D. Where calculated points (such as CFM) are shown, they shall appear in their respective logical groups. The respective unconditioned raw data (such as the logarithmic differential pressure) points shall also be grouped in a special group for display and observation independent of the logical groups.

E. Where data or control points are required to accomplish the digital control or energy management sequences specified but not listed in the summary, the Contractor shall notify the Architect in writing at least fourteen (14) days prior to bid opening. If this timely notification is not received by the Architect, all points required by the sequences shall be provided.

F. Unless otherwise specified or approved prior to bidding, the primary analog input and the analog output of each DDC loop shall be resident in a single remote panel containing the DDC algorithm, and shall function independently of any peer or mux communication links. Secondary (reset type) analog inputs may be received from the peer network, but approved default values and/or procedures shall be substituted in the DDC algorithm for this secondary input if network communications fail or if the secondary input becomes erroneous or invalid.

- END OF SECTION 23 09 00 -

SECTION 23 23 00
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. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: 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. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 3/8 inch equals 1 foot.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual 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.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.7 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. Refer to Details on the Drawings.

PART 2 - PRODUCTS

2.1 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 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless 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 (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

B. 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 (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

C. 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 (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

D. 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 (3450 kPa).

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an 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 1/2-inch (16-GRC) conduit adapter, and 24-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).
8. Manual operator.

F. Safety Relief Valves: Comply with 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 Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with ARI 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 (4.4 deg C).
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 (4820 kPa).

H. 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: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24-V ac coil.
8. End Connections: Socket.
9. Set Pressure: As required or recommended by the equipment manufacturer.
10. Throttling Range: Maximum 5 psig (34 kPa).
11. Working Pressure Rating: 500 psig (3450 kPa).
12. Maximum Operating Temperature: 240 deg F (116 deg C).

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

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 (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

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 ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Replaceable-Core Filter Dryers: Comply with ARI 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, as recommended by the equipment manufacturer.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: Refer to Drawings and Equipment Characteristics.
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Permanent Filter Dryers: Comply with ARI 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 or charcoal, as recommended by the equipment manufacturer.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: Refer to Drawings and Equipment Characteristics.
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

O. Receivers: Comply with ARI 495.

1. Comply with 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 (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.3 REFRIGERANTS

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. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 (DN 40) and Smaller or Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines:

1. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
2. NPS 4 (DN 100) and smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

E. All exposed refrigerant piping shall be hard copper. All concealed refrigerant shall be soft copper to minimize joints.

F. The Contractor shall coordinate with and install refrigerant piping based on the manufacturer's requirements. The Contractor shall make corrections at no additional cost if the installation deviates from the manufacturers requirements.

G. Provide isolation service valves at the branch selector box for each fan coil circuit.

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-sized, 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 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 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 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 soft copper piping throughout; exception: where piping is exposed, use hard copper pipe.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Install piping adjacent to machines to allow service and maintenance.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Refer to Division 23 Sections "Instrumentation and Control for HVAC" for solenoid valve controllers, control wiring, and sequence of operation.

L. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

M. 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 as specified in Division 23 if valves or equipment requiring maintenance is concealed behind finished surfaces.

N. Install refrigerant piping in protective conduit where installed belowground.

O. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

P. 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.

Q. 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.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "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 Division 23 Section "Escutcheons for HVAC Piping."

V. All brazing shall be performed using dry nitrogen.

W. Pressure test refrigerant piping with dry nitrogen at 500 PSI for two (2) hours minimum. Test shall be witnessed by the owner.

X. Triple evacuate to 500 microns. Use electron micron gauge.

Y. The equipment manufacturer shall inspect and sign off on the refrigerant piping installation prior to start-up of equipment. Submit on manufacturer's letterhead acceptance of the piping installation for operational purposes and warranty.

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. 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.

E. 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 restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. 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 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Copper-clad hangers with neoprene inserts and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 3/8 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 3/8 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 3/8 inch (6.4 mm).
   NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
4. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
5. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
6. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
7. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
8. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 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 using dry nitrogen 500 micrometers (67 Pa). Use electronic micron gauge. If vacuum holds for 12 hours, system is ready for charging. All tests shall be witnessed by the owner.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
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.

3.9 COORDINATION WITH THE MANUFACTURER

A. Review, coordinate, and have the manufacturer inspect, approve, and provide on letterhead all piping has been installed, charged, tested, and adjusted per the manufacturer’s requirements and state that the system and equipment warranty as specified will be provided to the owner.

- END OF SECTION 23 23 00 -

SECTION 23 31 13
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. Rectangular double wall ducts and fittings.
2. Single-wall round and flat oval ducts and fittings.
3. Double-wall round and flat oval ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealants and gaskets.
7. Hangers and supports.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "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 shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest ASHRAE 62 Standard.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. LEED Submittals: Comply with Section 018113

1. MR Credit 3: BPDO – Sourcing of Raw Materials.
   a. For recycled content ductwork: Documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include material cost valve.

2. EQ Credit 2: Low-Emitting Materials
   a. For interior wet-applied adhesives, sealants, mastics, paints and coatings: Documentation indicating compliance with the California Department of Public Health (CDPH) Standard Method V1.1-2010 and VOC content in g/l. Include volume of material applied per product.

C. 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 and vibration isolation.

D. 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: Calculation, for selecting hangers and supports.

E. 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, 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.

F. Welding certificates.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code
- Steel," for hangers and supports; AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports; AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, 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 1-4, "Transverse (Girth) 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 1-5, "Longitudinal Seams - Rectangular Ducts," 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 2, "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."

E. All kitchen hood, range hood and dishwasher exhaust ducts shall be 18 gauge minimum, type 304 stainless steel with welded joints and comply with NFPA 96.

F. Minimum duct gauge shall be 22 gauge.

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

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

1. McGill AirFlow LLC.
2. Lindab.
3. Semco.
4. Eastern Sheet Metal.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards
- Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent, unless otherwise noted to have solid sheet steel.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Traverse (Girth) 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."

I. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards
- Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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."

J. Provide 18 gauge minimum duct construction for the first ten (10) feet supply and return/relief ducts connected to all types of air handling units. This ductwork shall be internally lined (2”

thick) provided with perforated inner galvanized liner covering and externally insulated with rigid board insulation. Refer to Drawings for additional information.

K. All exterior ductwork shall be double wall, 18 gauge minimum.

L. Minimum duct gauge shall be 22 gauge.

M. All exposed ductwork shall be painted and be provided with paint grip finish.

2.3 SINGLE-WALL ROUND AND FLAT OVAL 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 of the following or equal:

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Eastern Sheet Metal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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 (1524 mm) in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards
- Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," 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 (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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."

F. All round ductwork shall be spiral type unless noted otherwise.

G. All fittings shall be fully welded type. Only use fittings as detailed on the Drawings. Straight tees and laterals are prohibited. Ninety-degree mitered elbows, bull head tees, and saddle taps are prohibited.

H. Exposed ducts shall have paint grip finish.

I. Minimum duct gauge shall be 22 gauge.

2.4 DOUBLE-WALL ROUND DUCTS AND FITTINGS

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

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Eastern Sheet Metal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt- welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards
   - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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."

D. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without

compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

F. All round ductwork shall be spiral type unless noted otherwise.

G. All fittings shall be fully welded type. Only use fittings as detailed on the Drawings. Straight tees and laterals are prohibited. Ninety-degree mitered elbows, bull head tees, and saddle taps are prohibited.

H. All exposed ducts shall be painted and have paint grip finish.

I. Minimum duct gauge shall be 22 gauge.

J. All exterior ductwork shall be double wall, 18 gauge.

2.5 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. Provide 18 gauge minimum duct construction for the first ten (10) feet supply and return ducts connected to roof- mounted air handling units. This ductwork shall be internally lined provided with solid inner galvanized liner covering and externally insulated with rigid board insulation.

C. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, 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 (ASTM B 209M) 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/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10- mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.6 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, provide products by Owens Corning or one of the following:

    a. CertainTeed Corporation; Insulation Group.
    b. Johns Manville.
    c. Knauf Insulation.
    d. Owens Corning.

2. Maximum Thermal Conductivity:

    a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
    b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.

3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
4. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

    a. Interior Wet Applied Adhesives: Comply with low emitting requirements in Division 01 Section “Suitable Design Requirements – LEED”.

B. 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- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick aluminum; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent 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 (12.7 m/s).
7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) 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 (12.7 m/s) or where indicated.

9. Secure insulation between solid 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.

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.

2.7 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. Interior Wet Sealants: Comply with low emitting requirements in Division 01 Section “Suitable Design Requirements – LEED”.

C. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches (102 mm).
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. Interior Wet Applied Sealants: Comply with low emitting requirements in Division 01 Section “Suitable Design Requirements – LEED”.

D. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. Interior Wet Applied Sealant: Comply with low emitting requirements in Division 01 Section “Suitable Design Requirements – LEED”.
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Interior Wet Applied Adhesives: Comply with low emitting requirements in Division 01 Section “Suitable Design Requirements – LEED”.
9. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
10. Service: Indoor or outdoor.
11. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

F. 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.
6. Interior Wet Applied Sealant: Comply with low emitting requirements in Division 01 Section “Suitable Design Requirements – LEED”.

G. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

H. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) 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.

2.8 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 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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.

2.9 OPEN END DUCTS (OED)

A. Whether indicated on plans or not, all open-ended ducts shall be provided with a protective screen.

B. All open-ended ducts shall be furnished with a heavy gauge aluminum insect screen. Screens shall be permanently installed in a removable frame, and the frame shall be attached to the open-ended duct in a neat, workmanship-like manner without any exposed edges or sharp surfaces.

C. Screen shall be attached to a 3/4-inch x 1/8-inch continuous galvanized perimeter frame. Install duct stiffeners greater than 16 inches in any direction at open-ended ducts.

2.10 FABRIC DUCT WITH TENSIONING SYSTEM

A. General
1. Description of work:
a. Extent of non-metal ductwork is indicated on drawings and by requirements of this section.
b. Types of non-metal ductwork required for this project include the following:
i. Textile Air Dispersion Products.

B. Quality assurance:
1. Building Codes and Standards:
a. Product must be Classified by Underwriter's Laboratories in accordance with the 25/50 flame spread / smoke developed requirements of NFPA 90-A and UL 2518.
b. All product sections must be labeled with the logo and classification marking of Underwriter's Laboratories.
2. Design & Quality Control
a. Manufacturer must have documented design support information including duct sizing; vent, orifice, and/or nozzle location; vent, orifice, and/or nozzle sizing; length; and suspension. Parameters for design, including maximum air temperature, velocity, pressure and textile permeability, shall be considered and documented.

C. Submittals:

1. Product Data: Submit manufacturer's specifications on materials and manufactured products used for work of this section.
2. Building Code Data: Submit UL file number under which product is Classified by Underwriter's Laboratories for both NFPA 90-A and UL 2518.
3. Provide detailed drawings confirming configuration of Fabric Tensioning System (components, support locations, segment lengths) and Textile Dispersion System (diameter, lengths, airflow, pressure, and textile permeability).
4. Provide detailed installation instructions for components to be installed.
5. Provide warranty and maintenance documentation.

D. Warranty:
1. Manufacturer must provide a 20 Year Product Warranty for products supplied for the fabric portion of this system as well as a Design and Performance Warranty.

E. Delivery, storage and handling:
   1. Protect textile air dispersion system and SkeleCore FTS components from damage during shipping, storage, and handling.
   2. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.

Products

A. Manufacturer:
   1. DuctSox® Corporation with Sedona XM Fabric Duct and Skelecore fabric tensioning system (or as approved equal).

B. Textile air dispersion system:
   1. SkeleCore FTS (Fabric Tensioning System): Air diffusers shall be constructed with internal tensioning frame.
      a. System shall cylindrically tension textile along the entire length of textile duct, including all fittings (crosses, elbows, reducers and tees).
      b. Tensioning system shall include full 360 degree tensioning and intermediate rings with quick connection spacer tubes concealed inside the fabric system.
      c. Interior structure to include multiple mechanically adjustable tension devices. To provide proper textile tensioning, structural and textile system shall be configured in segments of no more than 45 feet.
      d. Textile components supported solely by metal cylindrical rings.
      e. Each cylindrical ring shall require a vertical metal to metal cable safety attachment.
         a. Vertical supports are Galvanized steel with available lengths of 5'(standard), 10', 15', & 30'.
      f. Available for diameters from 8" – 84".

   2. Textile
      a. Sedona-Xm
         a. Textile Construction: Filament/filament twill polyester treated with a machine washable anti-microbial agent by the fabric manufacturer, fire retardant in accordance with UL 2518. Non-linting filament yarn to meet the requirements of ISO Class 3 environment.
         b. Air Permeability: 2 (+2/-1) CFM/ft^2 per ASTM D737, Frazier
         c. Weight: 6.8 oz. /yd^2 per ASTM D3776
         d. Warranty: 20 years with standard inlet velocity.
      b. Textile Color
         a. Custom

   3. Textile system fabrication requirements:
      a. Textile system to be constructed in modular lengths (zippered) with proper radial securing clips (inlets, endcaps and mid-sections) and top access zippers for vertical cable safety attachment.
      b. Integrated air dispersion shall be specified and approved by manufacturer. (select only those that apply)
         a. Linear Vents
            1. Air dispersion accomplished by linear vent and permeable fabric. Linear vents must be sized in 1 CFM per linear foot increments (based on .5" SP), starting a 1 CFM through 90 CFM per linear foot. Linear vent is to consist of an array of open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents. Linear vents should also be designed to minimize dusting on fabric surface.

2. Size of vent openings and location of linear vents to be specified and approved by manufacturer.

c. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via. zip screw fastener – supplied by contractor.
d. Inlet connection includes zipper for easy removal / maintenance.
e. Lengths to include required intermediate zippers as specified by manufacturer.
f. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.
g. End cap includes zipper for easy maintenance.
h. Each section of the textile shall include identification labels documenting order number, section diameter, section length, piece number, code certifications and other pertinent information.

4. Design parameters:
   a. Textile air diffusers shall be designed from 0.25” water gage minimum to 3.1” maximum, with 0.5” as the standard.
   b. Textile air diffusers shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).
   c. System overall design; diameter, length, airflow, operating static pressure and dispersion shall be designed or approved by the manufacturer.
   d. Do not use textile diffusers in concealed locations.
   e. Use textile air dispersion systems only for positive pressure air distribution components of the mechanical ventilation system.

INSTALLATION

A. Installation of textile air dispersion system:
   1. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.

B. CLEANING AND PROTECTION:
   1. Clean air handling unit and ductwork prior to the Fabric Duct system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.
   2. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.
   3. If the fabric duct systems become soiled during installation, they should be removed and cleaned following the manufacturers standard terms of laundry.

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 (25 mm), plus allowance for insulation thickness. All lined ductwork shall be double wall type.

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 sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "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. All ductwork shall be shipped and stored with ends and openings sealed. All open ducts shall be sealed at the end of each work day.

N. All Ductwork and grilles in and serving the pool area shall be type 304 Stainless Steel

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system. Round exposed ducts shall utilize joint o-ring seals.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet (6 m) in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches (38 mm) from bottom of duct.

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

3.4 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." All ducts shall be completely sealed, except for round exposed ducts, which shall utilize joint o-ring seals.

B. All ducts shall be sealed. As a minimum, seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class A.
4. Outdoor, Return-Air Ducts: Seal Class A.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class A.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class A.
8. Unconditioned Space, Return-Air Ducts: Seal Class A.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class B.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for

slabs less than 4 inches (100 mm) thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

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.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

B. All exposed ducts shall have paint grip finish. All ducts shall be painted.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

   a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   b. Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   c. Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   d. Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.

e. Outdoor Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. 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.
6. Give five days' advance notice for testing.
7. All duct testing shall be witnessed by the Testing and Balancing Company, and by the Owner's Representative.

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.

3.9 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

1. Ducts Connected to MUA Units, Space FCU and/or Terminal Units:

a. Pressure Class: Positive 2-inch wg (500 Pa).
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Energy Recovery/DOAS/RTU and Air Handling Units:

a. Pressure Class: Positive 2-inch wg (1000 Pa).
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.
e. Provide 18 gauge minimum double wall duct construction with perforated interior liner for the first twenty (20) feet supply and return ducts connected to all energy recovery and air handling units. Exterior ductwork shall be externally insulated with rigid board insulation with 20 mil venture clad jacket.
f. Provide 18 gauge minimum duct construction, internally lined with perforated inner liner for all of the stage, cafeteria, all cafeteria return air ductwork, gym and all exposed ductwork.
g. All pool ductwork (supply and return) shall be 18ga stainless steel, double wall with solid stainless steel inner liner.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Return Ducts:

1. Ducts Connected to MUA Unit, FCU and/or Terminal Units:

a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Energy Recovery/DOAS/RTU and Air Handling Units:

a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.
e. Provide 18 gauge minimum double wall duct construction with perforated interior liner for the first fifteen (15) feet supply and return ducts connected to all energy recovery and air handling units. Exterior ductwork shall be externally insulated with rigid board insulation with 20 mil venture clad jacket.
f. Provide 18 gauge minimum duct construction, internally lined with perforated inner

liner for all of the stage, cafeteria, gym and all exposed ductwork.

g. All pool ductwork (supply and return) shall be 18ga stainless steel, double wall with solid stainless steel inner liner.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg (500 Pa).
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.
e. Stage exhaust ductwork shall be 18 gauge.

2. Ducts Connected to Range Hoods and Commercial Kitchen Hoods: Comply with NFPA 96.

a. Exposed to View: Type 304, 18 gauge minimum, stainless-steel sheet, No. 4 finish.
b. Concealed: Type 304, 18 gauge minimum, stainless-steel sheet, No. 2D finish.
c. Welded seams and joints.
d. Pressure Class: Positive or negative 2-inch wg (500 Pa).
e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
f. SMACNA Leakage Class: 3.
g. Provide all approved duct cleanout/access doors as required by NFPA 96.

3. Ducts Connected to Dishwasher Hoods:

a. Type 304, 18 gauge minimum, stainless-steel sheet.
b. Exposed to View: No. 4 finish.
c. Concealed: No. 2D finish.
d. Welded seams and flanged joints with watertight EPDM gaskets.
e. Pressure Class: Positive or negative 2-inch wg (500 Pa).
f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
g. SMACNA Leakage Class: 3.

4. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

5. Ducts Connected to General Kitchen Exhaust Ductwork (Aluminum).
a. All general kitchen exhaust ducts shall be aluminum.
b. These exhaust systems are low pressure service (-)2”W.G.
c. All elbows are round. Squared elbows of 90 degrees are not permitted.
d. All joints are welded by gas fusion using rods of similar materials.
e. All dampers, manual and motorized, shall be aluminum.
f. These exhaust systems shall be fabricated and installed in strict accordance with requirements of SMACNA and NFPA.

6. Ducts Connected to Clothes Dryer (Round Aluminum Vent Ductwork):
   a. Aluminum Ducts: ASTM B209. Aluminum sheet, alloy 3003-H14. Aluminum connectors and band stock: Alloy 6061-T6 or of equivalent strength.
   b. Dryer vent round ductwork shall be 20 gauge (minimum) aluminum construction with die-stamped or fabricated fittings. Ducts shall be constructed for low pressure operation with longitudinal seam up. Provide cleanouts at all changes in direction exceeding 45 degrees.
   c. Fabricated elbows shall be the multi-piece type with each segment not exceeding 22-1/2 degrees. Throat radius of all elbows shall be equal to the duct diameter. Tees shall be the concealed type.
   d. Joints shall be the slip or flanged type. Do not use drive slip coupling bands. Make-up slip joints with duct sealer.
   e. Ducts for exhausting clothes dryers shall not be assembled with screws or other fastening means that extend into the duct and that would catch lint.
   f. Provide NFPA 90A approved flexible duct section at connection of dryer to ductwork.
   g. Dryer vents shall terminate with a stainless steel wall cap with integral gravity backdraft damper.
   h. Where clothes dryer vent ducts pass through walls, floors, or partitions, the space around the duct shall be sealed with non-combustible material and firestopped.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil and Terminal Units:

   a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Energy Recovery/DOAS and Air-Handling Units:

   a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

3. Ducts Connected to Equipment Not Listed Above:

   a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts:

   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

G. Liner:

1. Supply Air Ducts: Fibrous glass, Type I, 1 inch (25 mm) thick with perforated galvanized liner (double wall) unless noted otherwise. Diffuser plenums do not require an inner galvanized liner.
2. Return Air Ducts: Fibrous glass, Type I, 1 inch (25 mm) thick with perforated galvanized liner (double wall)

H. Double-Wall Duct Interstitial Insulation:

1. Lined ductwork shall be installed in exposed occupied areas (i.e., stage, gymnasium areas, pool, cafeteria, etc.).

2. Round exposed ductwork shall be paintable galvanized steel, double wall construction with perforated interior liner (solid Stainless steel inner liner for pool area) and self-sealing duct connectors, similar to Lindab.

3. Supply and Return Air Ducts: 1 inch (25 mm) thick unless otherwise noted.

4. All lined ductwork shall have a perforated galvanized inner liner unless indicated otherwise.

5. Line all fan coil unit supply and return ductwork.

6. Additionally, provide the following:

   a. Stage: Line all supply, return and exhaust/relief ductwork in its entirety with 2” thick acoustical duct liner.
   b. Gymnasium: Line all supply and return ductwork in its entirety.
   c. Cafeteria: Line all supply and return ductwork in its entirety.

7. Line twenty (20) feet of AHU/DOAS unit supply and return (relief/exhaust) ductwork.

I. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

   a. Velocity 1000 fpm (5 m/s) or Lower:

      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.

   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with air foil vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

   c. Velocity 1500 fpm (7.6 m/s) or Higher:

      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with air foil vanes complying with SMACNA's "HVAC

Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with air foil type vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. 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 (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90- degree elbow.
      2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90- degree elbow.
      4) Radius-to Diameter Ratio: 1.5.

   b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.

J. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.
   c. Refer to Drawing Details.

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 only permitted in existing duct. Provide only fittings detailed on the Drawings. All other fittings are prohibited.

   a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree conical tap.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Lo Loss fitting or 45-degree conical lateral.
   c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree conical lateral (or Lo Loss fitting where indicated on the Drawings).
   d. Refer to Drawing Details.

- END OF SECTION 23 31 13 -

SECTION 23 33 00
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. Manual volume dampers.
2. Control dampers.
3. Fire dampers.
4. Smoke dampers.
5. Combination fire and smoke dampers.
6. Corridor dampers.
7. Flange connectors.
8. Duct silencers.
9. Turning vanes.
10. Remote damper operators.
11. Duct-mounted access doors.
12. Flexible connectors.
13. Flexible ducts.
14. Duct accessory hardware.

B. Related Sections:

1. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Division 28 Section "Digital Addressable Fire Alarm System" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

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

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. 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.

C. 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.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

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 AMCA 500-D testing for damper rating.

1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 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/A 653M.

1. Galvanized Coating Designation: G60 (Z180).
2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide Ruskin MD-35 (Rectangular), Ruskin MDRS25 (Round), or comparable product by one of the following:

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. METALAIRE, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications with velocities to 1500 feet per minute and 3 inches w.g.
4. Frames:

   a. Hat-shaped, galvanized-steel channels, 0.064-inch (1.62-mm) minimum thickness.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   d. Two-inch insulation stand-off bracket with extended shaft rod.
   e. Hand Quadrant.

5. Blades:

   a. Multiple or single blade with blade stop.
   b. Opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 0.064 inch (1.62 mm) thick.
   e. Six-inche nominal width.

6. Blade Axles: Galvanized steel. Hex-shaped, mechanically attached to blade, minimum 1/2” diameter.
7. Bearings:

   a. Oil-impregnated bronze iolite bearings.
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide Ruskin MD-35 or comparable product by one of the following:

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.

d. METALAIRE, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts. Two-inch insulation. Stand-off bracket with extended shaft rod and hand quadrant.
5. Blades:

   a. Multiple or single blade with blade stop.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

6. Blade Axles: Minimum 1/2-inch diameter stainless steel.
7. Bearings:

   a. Oil-impregnated bronze, oillite bearings.
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

2.3 CONTROL DAMPERS (LOW LEAK)

A. Manufacturers: Subject to compliance with requirements, provide Ruskin CD60 or products by one of the following:

   1. American Warming and Ventilating; a division of Mestek, Inc.
   2. Arrow United Industries; a division of Mestek, Inc.
   3. Greenheck Fan Corporation.
   4. METALAIRE, Inc.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage. Leakage shall be less than 3 cfm/square foot at 1-inch static pressure/less than 8 cfm/square foot at 4 inches of static pressure, and is AMCA-Certified as a Class 1A damper.

C. Frames:

   1. 5” x 1” x 16 gauge hat channel shaped reinforced with corner braces.
   2. Galvanized -steel channels, 0.064 inch (1.62 mm) thick.
   3. Mitered and welded corners.
   4. Round, oval and rectangular duct transition connections shall be welded for high pressure.

D. Blades:

   1. Multiple blade with maximum blade width of 8 inches by 6 inches high.
   2. Parallel (2 position) and Opposed-blade (modulating) design.
   3. Galvanized or stainless steel.
   4. Double skin, airfoil type 14 gauge equivalent thickness.

5. Blade Edging: Neoprene blade edge seals and flexible metal compressible jamb seals.

E. Blade Axles: 1/2-inch- (13-mm-) hexagonal positively locked into the damper blade; galvanized or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Removable control shaft shall extend 6-inches beyond frame.

1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).

F. Bearings:

1. Permanently lubricated, corrosion-resistant stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.

2.4 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide Ruskin DIBD2 (Standard), FD60 (Multi-blade), FD 35/OW (Out of wall/floor) or products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Prefco; Perfect Air Control, Inc.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL, Leakage Class A.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Airfoil shaped, double skin, single piece construction with 14 gauge equivalent thickness, maximum 6” wide.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

K. Damper Style: “B” style for low pressure rectangular; “BC” style welded for medium pressure rectangular; “WR” style, welded for round transition applications; and “WO” style, welded for flat oval transition applications.

2.5 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide Ruskin SD 60 or products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.

B. General Requirements: Label according to UL 555S by an NRTL, Classified Class 1.

C. Smoke Detector: Integral, factory wired for single-point connection, no or low air flow type.

D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners. Round, oval and rectangular transition connections shall be one-piece airfoil, 6-inches wide and 16 gauge; welded type (WR, WD and WC).

E. Blades: Galvanized sheet steel blade seals, silicone edge type, mechanically fastened to the blade edge for smoke seal to 450 deg F. Jamb seals shall be stainless steel, flexible metal compression type. Bearings shall be stainless steel sleeve type, pressed into frame.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

I. Damper Motors: Modulating or two-position action. Refer to Sequence of Operation on the Drawings.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "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 23 Section "Instrumentation and Control for HVAC" and Division 26 Sections**.**
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 24 V, single phase, 60 Hz. Coordinate requirements with Divisions 23 and 26.

K. Accessories:

1. Auxiliary switches for signaling or position indication.
2. Test and reset switches, remote mounted.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide Ruskin FSD 60 or products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL, Leakage Class I.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Jamb Seals: Stainless steel, flexible metal compression type.

F. Heat-Responsive Device: Electric resettable fuse link and switch package, factory installed, 165 deg F rated.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Frame: 5” x 16 gauge galvanized hat-shaped channel. No flow rated. Multiple-blade type. Round, oval and rectangular duct transition connections shall be welded for high pressure.

I. Blades: Air-foil shaped, double skin, single piece construction with 14 gauge equivalent thickness, maximum 6” wide. Blade edge seals shall be silicone edge type for smoke seal up to 450 deg F and galvanized steel for frame seal to 1900 deg F.

J. Leakage: Class I.

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

M. Master control panel for use in dynamic smoke-management systems.

N. Damper Motors: Modulating or two-position action. Refer to Sequence of Operation on the Drawings.

O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "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 23 Section "Instrumentation and Control for HVAC" and Division 26 Sections**.**
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 24 V, single phase, 60 Hz.

P. Accessories:

1. Auxiliary switches for signaling or position indication.
2. Test and reset switches, remote mounted.

2.7 CORRIDOR DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide Ruskin FSD 60C or products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Nailor Industries Inc.

B. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-1/2-hour rating by an NRTL, Class 1.

C. Heat-Responsive Device: 165 deg F, electric resettable fuse link and switch package, factory installed, no flow rated duct detector.

D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

E. Blades: Airfoil shaped, double skin, single piece construction with 14 gauge equivalent thickness, maximum 6-inches wide. Blade seals shall be silicone edge type for smoke seal to 450 deg F and galvanized steel for frame seal to 1900 deg F. Bearings shall have stainless steel sleeve pressed into frame. Jamb seals shall be stainless steel, flexible metal compression type..

F. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

G. Damper Motors: Modulating or two-position action. Refer to Sequence of Operation on the Drawings.

H. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "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 23 Section "Instrumentation and Control for HVAC" and Division 26 Sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 24 V, single phase, 60 Hz.

2.8 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: Roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.9 DUCT SILENCERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Pottorff type RFN and EFN or comparable product by one of the following:

1. IAC.
2. Vibro-Acoustics.
3. Price.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275), galvanized sheet steel, 22 gauge thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, **G90 (Z275)**, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.052 inch (1.3 mm) thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, **G90 (Z275)** galvanized sheet metal, 16 gauge thick, and with 1/8-inch- (3-mm-) diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss.
3. Stainless steel construction when installed in stainless steel ductwork.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.

   a. Fill Material: Inert, vermin-proof and moisture-proof fibrous material, packed under not less than 5 percent compression.
   b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: None.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Lock form and seal or continuously weld joints.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:
1. Factory-installed end caps to prevent contamination during shipping.

L. Source Quality Control: Test according to ASTM E 477.
1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.
2. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

M. Capacities and Characteristics:

1. Configuration: Straight.
2. Shape: Rectangular and round.
3. Attenuation Mechanism: Acoustical glass fiber. Helmholtz resonator mechanism with no internal media.
4. Maximum Pressure Drop: Refer to Drawings.
5. Casing:
   a. Attenuation: Standard.
   b. Outer Material: Galvanized steel or stainless steel based on duct system construction.
   c. Inner Material: Galvanized steel or stainless steel based on duct system construction.
6. **V**elocity Range.
7. End Connection: 1-in (25-mm) slip joint for flange.
8. Length: Refer to Drawings.
9. Face Dimension: Refer to Drawings.
10. Face Velocity: Refer to Drawings.
11. Dynamic Insertion Loss: Refer to Drawings.
12. Generated Noise: Refer to Drawings.
13. Accessories: None.

2.10 TURNING VANES

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.
5. Ward Industries, Inc.; a division of Hart & Cooley, 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. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single and Double wall.

E. Vane Construction: Single wall for ducts up to 24 inches wide and double wall for larger dimensions.

2.11 REMOTE DAMPER OPERATORS

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. Pottorff; a division of PCI Industries, Inc.
2. Ventfabrics, Inc.
3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed, 2 inches (50 mm) deep.

F. Wall-Box Cover-Plate Material: Stainless steel.

2.12 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. McGill AirFlow LLC.
5. Nailor Industries Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - 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 (25-by-25-mm) 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 (300 mm) Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two 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 6-inch wg (2500 Pa).
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- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.13 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.; a division of Hart & Cooley, 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 3-1/2 inches (89 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) 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. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

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. (810 g/sq. m).

2. Minimum Tensile Strength: 500 lbf/inch (88 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

G. 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 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.14 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-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 (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
4. Insulation R-value: 6.0 at 72 deg F.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

2.15 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install 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. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire 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. Control devices requiring inspection.
8. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Minimum Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).

6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

K. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Do not use flexible ducts to change directions.

O. Connect diffusers and / or diffuser boxes to ducts directly or with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with draw bands plus sheet metal screws.

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 1/4-inch (6-mm) movement during start and stop of fans.

S. Install flanges around all ducts penetrating walls to provide a finished look. Sleeve and seal to be water and air tight.

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 23 33 00 -

SECTION 23 34 23
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. This Section includes the following:
   1. Centrifugal roof ventilators.
   2. Ceiling-mounting ventilators.
   3. In-line centrifugal fans.
   4. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and 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. Roof curbs.
   6. Fan speed controllers.

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. Wiring Diagrams: Power, signal, and control wiring.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

Coordination Drawings: Reflected ceiling 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:

4. Roof framing and support members relative to duct penetrations.
5. Ceiling suspension assembly members.
6. Size and location of initial access modules for acoustical tile.
7. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 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.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

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. Greenheck.
2. Loren Cook Company.
3. Twin City.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent for direct drive fans.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) pre-treated wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 18 inches (450 mm).
3. Sound Curb: Curb with sound-absorbing insulation matrix where indicated.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Mounting Pedestal: Galvanized steel with removable access panel.

H. Capacities and Characteristics: Refer to Mechanical Equipment Schedule for capacities.

2.2 CEILING-MOUNTING VENTILATORS

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. Greenheck.
2. Loren Cook Company.
3. Twin City.

B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

E. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Isolation: Rubber-in-shear vibration isolators.
5. Manufacturer's brick vent (as sized on the drawings) with custom color as selected by the Architect and transition fittings.
6. Provide in-line type where indicated on the drawings.

H. Capacities and Characteristics: Refer to Mechanical Equipment Schedules for capacities.

2.3 IN-LINE CENTRIFUGAL FANS

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. Greenheck.
2. Loren Cook Company.

3. Twin City.

B. Description: In-line, direct-driven centrifugal fans consisting of insulated housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing with whee4l inlet cone and motor on swing out service door.

E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and copper lubricating tubes from fan bearings extended to outside of fan housing.

F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

G. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent for direct drive fans.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: 1/2- by 1-inch (13- by 25-mm) 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.

H. Capacities and Characteristics: Refer to Mechanical Equipment Schedules for capacities.

1. Vibration Isolators:

a. Type: Elastomeric hangers.
b. Static Deflection: 1 inch (25 mm).

2.4 PROPELLER FANS

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. Greenheck.
2. Loren Cook Company.
3. Twin City.

B. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

C. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

D. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

F. Accessories:
1. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
2. Wall Sleeve: Galvanized steel to match fan and accessory size.
3. Weathershield Front Guard: Galvanized steel with expanded metal screen.
4. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

G. Capacities and Characteristics: Refer to Mechanical Equipment Schedules for capacities.

1. Vibration Isolators:

   a. Type: Elastomeric hangers or Spring isolators or Restrained spring isolators].
   b. Static Deflection: 1 inch (25 mm).

2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type and efficiency requirements for motors specified in Division 23 Section "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 25 sections.

B. Enclosure Type: Totally enclosed, fan cooled.

C. Provide ECM type where indicated on the drawings.

2.6 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using elastomeric mounts and spring isolators having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 23.

D. Secure roof-mounting fans to roof curbs with stainless steel hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.

E. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

F. Support suspended units from structure using threaded steel rods and elastomeric hangers and spring hangers having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

G. Install units with clearances for service and maintenance.

H. Label units according to requirements specified in Division 23 Section "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 Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

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. Verify lubrication for bearings and other moving parts.
7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
8. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
9. Shut unit down and reconnect automatic temperature-control operators.
10. Remove and replace malfunctioning units and retest as specified above.

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

3.4 ADJUSTING

A. Adjust belt tension.

B. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

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

D. Lubricate bearings.

- END OF SECTION 23 34 23 -

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. Heavy duty round ceiling diffuser.
2. Louver face diffusers.
3. Linear slot diffusers.
4. Heavy Duty Register.
5. Ceiling and Sidewall Return and Exhaust Grilles.
6. Adjustable Bar Supply Registers – Standard.
7. Adjustable Bar Supply Registers – Spiral Duct-Mounted.
8. Egg Crate Grille.
9. Door Transfer Grille.

B. Related Sections:

1. Division 08 Section "Fixed Louvers" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 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.
3. Diffusers, registers, and grilles shall be tested in accordance with ANSI/ASHRAE 70-1991.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. 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.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Heavy Duty Round Ceiling Diffuser:
1. Basis-of-Design Product: The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Subject to compliance with requirements, provide Titus XC-310 or comparable product by one of the following:
   a. METALAIRE, Inc.
   b. Price Industries.
   c. Krueger.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Diffuser shall be constructed of 18 gauge steel with a contoured outer core to guard against ceiling smudging and an inner vane assembly.
4. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with as 50-inch pound force applied.
5. Mounting: Duct connection shown on air device schedule.
6. Pattern: The airflow discharge pattern shall be field adjustable from horizontal to vertical by rotating a ring operator to open (vertical discharge) or close (horizontal discharge) the inner vane assembly. The inner vane assembly must be easily removable as a unit. The ring operator shall be adjustable with a pole of remote access.
7. Accessories:
   a. Equalizing grid.
   b. Internal safety chains.

B. Square and Rectangular Louver Face Diffuser:
1. Basis-of-Design Product: The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Subject to compliance with requirements, provide Titus Model TDC, TDV and TDCA as indicated on the drawings or comparable product by one of the following:
   a. Krueger.
   b. METALAIRE, Inc.
   c. Price Industries.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Construction shall be of steel except for the Kitchen which shall be aluminum.
4. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a

100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

5. Face Size: 24” x 24” for T-bar ceilings.
6. Mounting: Border Type 3 for lay-in ceilings, Border Type 1 for surface-mounting and Border Type 6, beveled drop face, for exposed locations. Refer to Architectural Drawings for finish type.
7. Pattern: An inner core assembly consisting of fixed deflection louvers shall be available in 1, 2, (2-way opposite and 2-way corner) 3, or 4-way horizontal discharge patterns. The inner core assembly must be removable in the field without tools for easy installation or cleaning.
8. Accessories: Equalizing Grid.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser:

1. Manufacturers: The manufacturer shall provide published performance data for the linear slot diffuser. The linear slot diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Subject to compliance with requirements, provide products by Titus ML Series or comparable product by one of the following:
   a. Krueger.
   b. METALAIRE, Inc.
   c. Price Industries.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: The frame and support bars shall be constructed of heavy gauge extruded aluminum.
4. Material - Pattern Controller and Tees: The pattern controller shall be an aerodynamically curved ice-tong shaped steel deflector capable of 180 degree pattern adjustment from the face of the diffuser and shall allow dampering if required. Maximum pattern controller length shall be 3 feet. For diffusers longer than 3 feet, pattern controllers shall be furnished in multiple sections.
5. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
6. Finish – Pattern Controller: #84 Black.
7. Slot Width: 1/2 inch, 3/4 inch, 1 inch, slot spacing of sizes shown on plans.
8. Number of Slots: 1 to 8 as shown on Plans.
9. Length: Shown on Plans.
10. Accessories: Linear slot diffusers shall be available in standard one-piece lengths up to 6 feet and 1 to 8 discharge slots. Diffuser lengths greater than 6 feet shall be furnished in multiple sections and will be joined together end-to-end with alignment pins to form a continuous slot appearance. All alignment components are to be provided by the manufacturer.
    a. Adjustable Pattern Controller.
    b. Frame and Border Type 4 with flange border, concealed mounting.
    c. Type X-X End Border.

2.3 REGISTERS AND GRILLES

A. Heavy Duty Register:

1. Basis-of-Design Product: The manufacturer shall provide published performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Subject to compliance with requirements, provide Titus Model 33-R, one-half-inch bar spacing and 38 degree deflection or comparable product by one of the following:
   a. Metallaire, Inc.
   b. Krueger.
   c. Nailor Industries Inc.
   d. Price Industries.

2. Material: Material shall be 16 gauge steel border and 14 gauge steel blades.
3. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with as 50-inch pound force applied.
4. Face Arrangement: As shown on the Device Schedule..
5. Deflection Bars: The fixed deflection bars shall be parallel to the long or short dimension (parallel with the floor) of the grille or register. Bars shall be 14 gauge steel. Bars shall be reinforced by perpendicular, steel support bars spaced on six-inch maximum centers.
6. Frame: One and one-quarter-inch border width on all sides and a minimum border gauge thickness of 16. Corners shall be welded with full penetration resistance welds with a reinforcing patch for extra strength.
7. Mounting Frame: Refer to Architectural Drawings for finish type.
8. Mounting: Countersunk screw.

B. Fixed Face Ceiling and Sidewall Return and Exhaust Grille:

1. Manufacturers: The manufacturer shall provide published performance data for the grilles. The grilles shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. For filter return grilles, provide one-inch thick filters and 1/4-turn fasteners. Subject to compliance with requirements, provide Titus – Series 350 RL, Series 350 RLF1or comparable product by one of the following:
   a. Krueger.
   b. Price Industries.
   c. Metallaire, Inc.

2. Material: Construction shall be steel except for Science/Prep/Storage Rooms, Janitor Closets, Locker Rooms, Laundry Rooms, Shower Rooms, Kitchen and Dining Areas, which shall be aluminum.
3. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
4. Face Size: 24” x 24” for lay-in ceilings, as shown on Air Device Schedule (3/4” blade spacing).
5. Deflection Blades: The fixed deflection blades shall be parallel to the long dimension (or the floor for sidewall installations) of the register. Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be firmly held in place by mullions from behind the grille and fixed in place by crimping or welding. Blade deflection angle shall be available at 35 degrees.

6. Frame: One and one-quarter-inch border width on all sides and a minimum border gauge thickness of 16. Corners shall be welded with full penetration resistance welds with a reinforcing patch for extra strength.
7. Mounting Frame: Border Type 3 for lay-in ceilings, Border Type 1 for surface mount or exposed conditions. Refer to Architectural Drawings for finish type.
8. Mounting: Countersunk screw.

C. Adjustable Bar Supply Air Register (Standard Type)
1. Basis-of-Design Product: The manufacturer shall provide published performance data for the diffuser. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Subject to compliance with requirements, provide Titus 300RS, double deflection register or comparable product by one of the following:
   a. METALAIRE, Inc.
   b. Price Industries.
   c. Krueger.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Register shall be constructed of steel with 1-1/4” wide border on all sides.
4. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
5. Mounting: Shown on air device schedule.
6. Deflection: Double deflection with blades spaced on 3/4” centers. Blades shall have steel friction pivots on both ends to allow for individual blade adjustment. Front blades shall be parallel to the short dimension.
7. Accessories:

   a. Equalizing grid.
   b. Volume Extractor AG-45 with operator.

D. Adjustable Bar Supply air Register (Spiral Duct-Mounted Register):
1. Basis-of-Design Product: The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Subject to compliance with requirements, provide Titus S300FS direct duct-mounted, double deflection with radius end caps or comparable product by one of the following:
   a. METALAIRE, Inc.
   b. Price Industries.
   c. Krueger.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Diffuser shall be constructed of heavy duty extruded aluminum frame with 1-3/8” wide border and radius end caps with foam gaskets. Blades shall be constructed of heavy gauge extruded aluminum, 3/4” spacing and face blades parallel to the short dimension. Blades shall be individually adjustable.
4. Finish: The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315 deg F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM D117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250 hour ASTM 0870 Water Immersion Test. The paint must also pass the ASTM D-2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
5. Mounting: Shown on air device schedule.

6. Pattern: The airflow discharge pattern shall be field adjustable from horizontal to vertical by rotating a ring operator to open (vertical discharge) or close (horizontal discharge) the inner vane assembly. The inner vane assembly must be easily removable as a unit. The ring operator shall be adjustable with a pole of remote access.
7. Dampers: Round damper shall be constructed of heavy gauge steel. Damper must be operable from the face of the diffuser by removing the inner vane assembly.
8. Accessories:

    a. Air Scoop Damper Model ASD.

E. Eggcrate Grille:
1. Basis-of-Design Product; Subject to compliance with requirements, provide Titus 50F and 50FF for filter grille, or comparable product by one of the following:
    a. Krueger.
    b. Price Industries.
    c. METALAIRE, Inc.
2. Material: Aluminum.
3. Finish: Same as all others.
4. Face Arrangement: 1/2 by 1/2 by 1/2 inch (13 by 13 by 13mm grid).
5. Core Construction: Integral aluminum core.
6. Frame: 1-1/4 inches (32 mm) wide.
7. Mounting Frame: Filter where indicated.
8. Mounting: countersunk screw for surface-mount (Border Type 1) and (Border Type 3) for T-bar ceiling.
9. Accessory One-inch filter with 1/4-turn fastener.

F. Door Transfer Air Grille:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus T700L with auxiliary frame or comparable product by one of the following:
    a. Krueger.
    b. Price Industries.
    c. METALAIRE, Inc.
2. Material: 20 gauge steel.
3. Finish: Same as all others.
4. Deflection Bars: Inverted “V” blades with a deflection angle of 77 degrees (site proof).
5. Frame: 1-1/4 inches (32 mm) wide.
6. Mounting Frame: Surface mount with auxiliary frame.
7. Mounting: Countersunk screw.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

B. Air devices located in locker rooms, the kitchen and science rooms shall be aluminum construction. Air devices located in the pool area and in pool ductwork shall be stainless steel. Refer to drawings and air device schedule for additional requirements.

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 23 37 23
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. Louvered-penthouse ventilators.
2. Roof hoods.
3. Goosenecks.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural performance requirements and design criteria indicated.

B. 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.

1. Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft. (960 Pa), acting inward or outward.

C. 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.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

D. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1-2004.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. For louvered-penthouse ventilators specified to bear AMCA Seal, include printed catalog pages showing specified models with a appropriate AMCA-Certified Ratings Seals.

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.

C. 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.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. 4 finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use Phillips flat -head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Greenheck Fan Corporation.
   2. Loren Cook Company.
   3. Ruskin.

B. Construction: All-welded assembly with 4-inch (100-mm)-deep louvers, mitered corners, and aluminum sheet roof with mineral-fiber insulation and vapor barrier.

C. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch (2.0 mm) for frames and 0.080 inch (2.0 mm) for blades.
   1. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.
   2. AMCA Seal: Mark units with the AMCA-Certified Ratings Seal.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

   1. Configuration: Self-flashing without a cant strip, with mounting flange.
   2. Height: 18 inches (450 mm) above finished roof.

E. Screening: Aluminum, bird screen.

F. Capacities and Characteristics: Refer to Mechanical Drawings for capacities.

2.4 GOOSENECKS

A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 5-5; with a minimum of 0052-inch –(1.3-mm) thick, galvanized steel sheet.

B. Roof Curbs; Galvanized steel sheet; with mitered and welded corners; 1-1/2-inch (40-mm) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.
   1. Configuration: Self-flashing without a cant strip, with mounting flange.
   2. Overall Height: 18 inches (450 mm).

C. Screening: Aluminum, bird screen.

D. Galvanized Steel Sheet Finish:
   1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

E. Capacities and Characteristics: Refer to Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install goosenecks on curb base where throat size exceeds 9 by 9 inches (230 by 230 mm).

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.

F. Label gravity ventilators according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

G. 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.

H. 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.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

- END OF SECTION 23 37 23 -

SECTION 23 73 33
INDIRECT-FUEL-FIRED HEATING AND VENTILATING 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. This Section includes indoor and or outdoor indirect-fired H&V units and make-up air units with the following accessories:

1. Gas furnace.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and methods of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
2. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Roof-mounted units and roof-curb mounting 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. Size and location of rooftop unit mounting rails and anchor points and methods for anchoring units to curb.
2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

D. Startup service reports.

E. Operation and Maintenance Data: For indirect-fired H&V units to include in emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of indirect-fired H&V units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 COORDINATION

A. Coordinate size, location, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below of indirect-fired H&V units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.

2. Three (3) year warranty from substantial completion for the remainder of the unit.

1.7 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. Filters: Three sets for each unit.
2. Fan Belts: Two sets for each unit.

PART 2 - PRODUCTS

2.1 INDOOR MAKE-UP AIR UNITS (GAS)

A. General: Make-up air unit shall be as manufactured by Greenheck, Model IGX, or one of the following alternate manufacturers: Gaylord or Captive-Air Systems, Inc., provided all Specifications are met. Performance to be as scheduled on plans.

B. Furnace and Controls: Indirect-fired furnace shall be 80% efficient, AGA design-certified, CGA approved and have a blow-through fan design. Furnace shall be capable of operation with natural gas and have a power venting system. The burner and heat exchanger shall be constructed of stainless steel. Standard furnace features shall include main gas pressure regulator, main gas valve, electronic modulating controls, electronic direct spark ignition system, high limit gas pressure regulator, and a 24-volt control transformer. Furnace shall be insulated and have double wall construction.

C. Unit Casing and Frames: Unit shall be of internal frame type, construction of galvanized steel. All frames and panels shall be G90 galvanized steel. Where top panels are joined, there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces exposed to the weather shall be sealed, requiring no caulking at job site. All components shall be easily accessible through removable doors.

D. Insulation: Down turn plenum shall be lined with 1" fiberglass insulation. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit.

E. Fan Section: Centrifugal fans shall be double width, double inlet. Fan and motor shall be mounted on a common base and shall be internally isolated. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently lubricated ball bearings (up to size 118) or ball bearing pillow blocks (size 120 and larger). Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged speeds. Provide extended copper lubrication lines for all bearings.

F. Motors and Drives: Motors shall be Premium efficiency type, totally enclosed fan-cooled. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be cast and have machined surfaces. Units shall be supplied with an adjustable drive multiple belt pulley.

G. All internal electrical components shall be prewired for single point power connection. All electrical components shall be UL listed, recognized, or classified where applicable and wired in compliance with the National Electrical Code. Control center shall include motor starter(s), control circuit fusing, control transformer for 120 VAC circuit, integral door interlocking disconnect switch with separate motor fusing and terminal strip. Contactors, Class 20 adjustable overload protection and single phase protection shall be standard.

H. Filter Section: Filters shall be mounted in a V-bank arrangement such that velocities across the filters do not exceed 550 feet per minute. Filter shall be easily accessible through a removable access panel. Filters shall be 2" thick FARR 30/30, 30% efficiency type.

I. Weather Hood: Weather hood shall be constructed of G90 galvanized steel with bird screen mounted at the intake.

J. Air Filter Gauge: Indicates when filters become dirty. An indicator light shall be mounted in the Penthouse local control panel. Coordinate requirements with the ATC Contractor.

K. Motorized dampers: Intake dampers shall be provided to prevent backdrafts when the fan is not in operation. Intake dampers shall be factory-mounted and wired. Coordinate requirements with the ATC Contractor.

L. Spring Vibration Isolators shall be provided.

M. Inlet Air Sensor: An on/off type duct stat automatically de-energizes the gas system and interrupts the flow of gas to the burner when the inlet air temperature is above the desired setting.

N. Freeze Protection: An on/off type discharge duct state (with a timer) prevents the discharge of cold air into the building when the burner is not providing adequate tempering.

O. Foil-faced Fiberglass insulation shall be provided to line the housing to prevent the formation of condensation and to form an acoustical barrier.

P. Discharge Temperature Control with Room Override: Provide electronic modulation furnaces which enable a room temperature sensor to reset the supply air discharge temperature setpoint above the minimum 60 deg F (adjustable and resettable through software). Discharge sensor shall be factory-installed on down discharge units. Room sensor shall be wall mounted. All sensors shall be by the ATC/EMS Contractor interfaced with the make-up air unit controller. Coordinate requirements with the ATC Contractor for a fully coordinated and functional system.

Q. Hood and Makeup Unit Control System: Provide Melink Intelli-Hood Control System or equal of Greenheck or Captive Air. System shall consist of:

1. System controller.
2. Hood controller.
3. Touchpad programming panel.
4. Optic sensors.
5. Air purge unit.
6. Temperature sensor.
7. Variable speed drives (ABB).

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 installation of indirect-fired H&V units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.

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

3.2 INSTALLATION

A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

B. Install roof curb on roof structure, according to ARI Guideline B**.** Install and secure indirect-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.

C. Install controls and equipment shipped by manufacturer for field installation with indirect-fired H&V units.

D. Install all demand controlled kitchen ventilation system in a fully turnkey fashion.

3.3 CONNECTIONS

A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.

1. Gas Piping: Comply with requirements in Division 22. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.

B. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to indirect-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 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 for visible damage to furnace combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.
11. Start unit according to manufacturer's written instructions.
12. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for run-in period recommended by manufacturer.
15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Gas Burner:

        1) Measure gas pressure at manifold.
        2) Measure combustion-air temperature at inlet to combustion chamber.
        3) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

16. Calibrate thermostats.
17. Adjust and inspect high-temperature limits.
18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.

19. Start evaporative cooler system and measure and record the following:

    a. Leaving-air, dry- and wet-bulb temperatures.
    b. Entering-air, dry- and wet-bulb temperatures.

20. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
21. Measure and record airflow. Plot fan volumes on fan curve.
22. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

23. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

D. Prepare written report of the results of startup services.

3.5 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 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain indirect-fired H&V units and demand controlled ventilation system.

- END OF SECTION 23 73 33 -

SECTION 23 74 13
PACKAGED, OUTDOOR, CENTRAL-STATION 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. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Direct-expansion cooling.
2. Hot-gas reheat.
3. Gas furnace.
4. Economizer outdoor- and return-air damper section.
5. Terminal strip for temperature controls.
6. Roof curbs.
7. Heat recovery wheel.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

F. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

G. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

H. VVT: Variable-air volume and temperature.

1.4 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

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.

C. LEED Submittals: Comply with Section 018113
   1. EQ Credit 3: Construction indoor air quality management.
      a. For filter media installed during construction and prior to occupancy, documentation indicating MERV rating or filter class.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: 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. Structural members to which RTUs will be attached.
   2. Roof openings
   3. Roof curbs and flashing.

B. Field quality-control test reports.

C. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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. Fan Belts: Three (3) sets for each belt-driven fan.
   2. Filters: Three (3) sets of filters for each unit.

1.8 QUALITY ASSURANCE

A. ARI Compliance:

   1. Comply with ARI 203/110 and ARI 303/110 for testing and rating energy efficiencies for RTUs.
   2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

   1. Comply with ASHRAE 15 for refrigeration system safety.

2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

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.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Refrigeration System: Parts, labor and loss of refrigerant for five (5) years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than ten (10) years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide AAON or a comparable product by one of the following:
1. Greenheck.
2. Daikin
3. Venmar.
4. Trane
5. Valent
6. Mitsubishi

2.2 CASING

General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Exterior Casing Material: 18 gauge minimum galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

A. Inner Casing Fabrication Requirements:

1. Inside Casing: 24 gauge minimum G90 galvanized steel,

B. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071, Type I.
2. Thickness: Two (2) inches.
3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Condensate Drain Pans: Formed sections of stainless steel sheet, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple .
3. Pan-Top Surface Coating: Corrosion-resistant compound.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.3 FANS

A. Direct-Driven Supply-Air Fans: Airfoil Plenum Fan, centrifugal; with permanently lubricated, variable speed drive motor with shaft grounding ring resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.

C. Relief-Air Fan Backward inclined, shaft mounted on permanently lubricated motor.

D. Fan Motor: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

E. Provide variable speed drives for all fans.

2.4 COILS

A. Supply-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

B. Outdoor-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.

2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

C. Hot-Gas Reheat Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

2.5 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: Two (2) minimum.

B. Compressor: Hermetic, Digital or variable speed Scroll type, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

C. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Modulating Hot-gas reheat valve.
11. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.6 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated: Minimum MERV 13.

2.7 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.

Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

D. Safety Controls:

1. Gas Control Valve: Modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.8 DAMPERS

A. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

1. Damper Motor: Modulating with adjustable minimum position.
2. Relief-Air Damper: motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

2.9 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC."

B. Basic Unit Controls:

1. Control-voltage transformer.
2. Factory provided controls package. Coordinate requirements with the required sequence of operations and the ATC Contractor.

2.11 ACCESSORIES

A. Hail guards of galvanized steel, painted to match casing.

2.12 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C 1071, Type I or II.
b. Thickness: 1-1/2 inches (38 mm).

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

   a. Liner Adhesive: Comply with ASTM C 916, Type I.
   b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
   d. Liner Adhesive: Comply with ASTM C 916, Type I.

B. Curb Height: 18 inches minimum above finished roof.

2.13 HEAT RECOVERY WHEEL

A. Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework (designed to produce laminar air flow through the wheel), an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt with a five year warranty. The wheel media shall be a polymer film matrix in a stainless steel framework and be comprised of individual segments that are removable for servicing. Non-segmented energy wheels are not acceptable. Molecular sieve desiccant shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.

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 RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

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

3.2 INSTALLATION

A. Equipment Mounting:
   1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTUs on curbs and coordinate roof

penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to RTUs to allow service and maintenance.

1. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.
5. Install light-weight, (30-35 PCF) Acoustical Pearlite concrete mix inside roof curb, 4 inches (100 mm) thick.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

3.5 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 do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.

    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

27. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.

29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Refer to Section 230500 for additional information.

- END OF SECTION 23 74 13 -

SECTION 23 74 33
DEDICATED OUTDOOR-AIR 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 factory-packaged and factory-split High percentage of outdoor air units (AHU's) and capable of supplying up to 100 percent outdoor air (DOAS) while providing cooling/dehumidification, free reheat, heat recovery and heating. This section includes units with integral heating and cooling for outdoor installation. Integral Energy Recovery device shall be a rotary air-to-air total enthalpy wheel. Integral heat source shall be Indirect Gas-Fired furnace. Integral cooling source shall be packaged or split/remote air cooled DX condensing unit. DOAS units shall be 100% Outdoor Air only. High percentage AHU's shall have return air capability and be similar in style and type as the DOAS units. Refer to drawings for additional information and details. Refer to Control drawings for additional requirements. All controls shall be coordinated at the time of bid with the ATC contractor for a fully turnkey installation. Provide integral refrigeration/dehumidification/gas heat and safety controls and terminal strip for field mounted ATC unit controls. Each unit shall be constructed in a horizontal configuration and shall incorporate additional product requirements as listed in Section 2 of this specification and as indicated on the contract drawings.

1.3 ACTION SUBMITTALS

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

1. Complete fan performance curves for both Supply Air and Exhaust Air, with system operating conditions indicated, as tested in AMCA Certified Chamber.
2. Sound performance data for both Supply Air and Exhaust Air, as tested in an AMCA Certified Chamber.
3. Motor ratings, electrical characteristics and motor and fan accessories.
4. Performance ratings for all chilled water or DX coils.
5. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
6. Estimated gross weight of each installed unit.
7. Installation, Operating and Maintenance manual (IOM) for each model.
8. Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
9. AHRI Certified coil performance ratings with system operating conditions indicated. Ratings shall be in accordance with Standard 410.
10. Energy wheel performance data for both summer and winter operation.

Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1,

B. Shop Drawings:

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. Prepare the following by or under the supervision of a qualified professional engineer:

a. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
b. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-curb mounting 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. Size and location of unit-mounted rails and anchor points and methods for anchoring units to roof curb.
2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

B. Startup service reports.

C. LEED Submittals: Comply with Section 018113
1. EQ Credit 3: Construction indoor air quality management.
a. For filter media installed during construction and prior to occupancy, documentation indicating MERV rating or filter class.

D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For 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: Three (3) sets for each unit.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Five years from date of Substantial Completion.

2. Warranty Period for Heat Exchangers: Five 10 years from date of Substantial Completion.

1.8 QUALITY ASSURANCE

A. Source Limitations: Obtain unit with all appurtenant components or accessories from a single manufacturer.

B. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.

C. Product Options: Drawings must indicate size, profiles and dimensional requirements of unit and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".

D. Certifications

1. Blowers shall be AMCA Certified for air flow.
2. Entire unit shall be ETL Certified per U.L. 1995 and bear an ETL sticker.
3. Energy Wheel shall be AHRI Certified, per Standard 1060.
4. Coils shall be Recognized Components for ANSI/UL 1995, CAN / CSA C22.2 No. 236.05. DX and water coils shall be AHRI Certified per standard 410-2001.
5. Indirect gas-fired furnace shall be ETL Certified as a component of the ERU. Indirect gas-fired furnace shall be an ETL Recognized Component of the ERU per ANSI Z83.8.

1.9 COORDINATION

A. Coordinate size and location of all building penetrations required for installation of each unit and associated plumbing and electrical systems.

B. Coordinate location of water system fittings to ensure correct positioning for connection to the water coil and condensate drain pipe.

C. Coordinate sequencing of construction of associated plumbing. HVAC, electrical supply.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, exhaust air blower, evaporator coil, energy recovery wheel, hot gas reheat coil, indirect gas-fired furnace, packaged DX system, phase and brownout protection, motorized dampers, filter assembly intake air, supply air blower assembly, exhaust/relief blower assembly, filter assembly for exhaust air, terminal control strip and an electrical control center. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection.

B. Basis-of-Design Product: Subject to compliance with requirements, provide AAON as indicated on Drawings or comparable product by one of the following:
1. Greenheck.

2. Daikin.
3. Venmar.
4. Trane
5. Valent
6. Mitsubishi
7. Engineered Air

2.2 PERFORMANCE REQUIREMENTS

A. General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

2.3 CABINET

A. Material: Formed, double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.

1. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish. Pre-painted components as supplied by the factory shall have polyester urethane paint on 18 gauge G60 galvaneal steel. Components that receive a painted finish per A / E specification shall be painted with a polyester urethane powder coat
2. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.

B. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL181.

1. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.
   a. Thickness: 2 inch (50 mm).
   b. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.

C. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvannealed steel.

D. Condensate Drain Pans: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.

E. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.

2.4 SUPPLY AND EXHAUST FAN

A. Supply and Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.

B. Forward-Curved Fan Type: Centrifugal; statically and dynamically balanced.

1. Fan Wheel Material: Galvanized steel, mounted on solid-steel shaft.
   Bearings: Self-aligning, permanently lubricated ball bearings.

C. Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

1. Fan Wheel Material: Aluminum; attached directly to motor shaft.
2. Fan Wheel Drive and Arrangement: Direct drive, AMCA Arrangement 4.
3. Fan panel and frame Material: Powder-coated steel, stainless steel, or aluminum.
4. Fan Enclosure: Easily removable enclosure around rotating parts.
5. Fan Balance: Precision balance fan below 0.08 inch/s (2.0 mm/s) at design speed with filter in.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open dripproof.
3. Enclosure Materials: Cast iron.
4. Efficiency: Premium efficient. Inverter duty rated type with shaft grounding ring.
5. Service Factor: 1.15.
6. Provide variable speed drive.

E. Blower:

1. Blower Section Construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.
2. Blower Assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
3. Fan: Airfoil plenum fan statically and dynamically balanced, AMCA certified for air and sound performance, mounted on ground and polished steel fan shafts with bail bearing pillow blocks. Bearings shall be selected for a minimum L10 life in excess of 50,000 hours at maximum catalogued speeds.
4. Blower Section Motor Source Quality Control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, “Laboratory Methods of Testing Fans for Rating”.

2.5 COOLING COILS

A. Capacity Ratings: Comply with ASHRAE 33 and ARI 410.

B. Evaporator Coil: Evaporator coil shall be AHRI Certified and shall be (silver) soldered or brazed into the compressed refrigerant system. Coil shall be constructed of copper tubing, permanently bonded to aluminum fins and enclosed in a galvanized steel frame. If two compressors are used as components of the unit, then the evaporator col shall be of “interlaced” configuration, permitting independent operation of either compressor without conflict with the with the other compressor.

2.6 REFRIGERATION SYSTEM

A. Comply with requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."

B. Refrigerant Charge: Factory charged with refrigerant and filled with oil.

C. Packaged DX System: Unit shall have an integral digital scroll compressor(s) and evaporator coil located within the weather-tight unit housing. Condenser coils and appurtenant condenser fan assemblies shall be factory installed as integral subassemblies of the unit and mounted on the exterior of the unit. Condenser fan motors shall be three phase, type 56 frame, Open Air Over and Shaft Up. Each condenser fan motor shall have a vented frame, rated for continuous duty and be equipped with an automatic reset thermal protector motors shall be UL Recognized and CSA Certified. The refrigerant compressor(s) shall be digital hermetic scroll-type and shall be equipped with liquid line filter drier, thermostatic expansion valves (TXV)(s), manual reset high pressure and low pressure cutouts and all appurtenant sensors, service ports and safety devices. Compressed refrigerant system shall be fully charged with R-410A refrigerant. Each compressor shall be factory-equipped with an electric crankcase heater to boil off liquid refrigerant from the oil.

D. Refrigeration System Specialties:

1. Expansion valve with replaceable thermostatic element.
2. Refrigerant dryer.
3. High-pressure switch.
4. Low-pressure switch.
5. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
6. Brass service valves installed in discharge and liquid lines.

E. Capacity Control:

1. Digital or variable speed scroll with capacity control and continuous dehumidification on a single compressor down to 10%.

F. Refrigerant condenser and modulating hot gas reheat condenser coils:

1. Capacity Ratings: Complying with ASHRAE 33 and ARI 410.
2. Tube Material: Copper.
3. Fin Material: Aluminum.
4. Fin and Tube Joint: Mechanical bond.
5. Leak Test: Coils shall be leak tested with air underwater.
6. Coating: Phenolic epoxy corrosion-protection coating after assembly.

G. Outdoor ACCU Condenser Fan Assembly:

1. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades.
2. Fan Motors:

   a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Motor Enclosure: Totally enclosed non-ventilating (TENV) or totally enclosed air over (TEAO) enclosure.
   c. Enclosure Materials: Cast iron.
   d. Motor Bearings: Permanently lubricated bearings.

e. Built-in overcurrent and thermal-overload protection.
f. Efficiency: Premium efficient.

3. Fan Safety Guards: Steel with corrosion-resistant coating.

H. Safety Controls:

1. Compressor motor and condenser coil fan motor low ambient lockout.
2. Overcurrent protection for compressor motor.

2.7 INDIRECT-FIRED GAS FURNACE HEATING

A. Furnace Assembly:

1. Factory assembled, piped, and wired.
2. Comply with requirements in NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
3. AGA Approval: Designed and certified by and bearing label of AGA.
4. Shall be ETL Certified as a component of the unit.
5. Shall be ETL Certified for installation downstream of a cooling coil.

B. Burners:

1. Heat-Exchanger Material: Shall have 4-pass tubular heat exchangers, constructed of type 409 stainless steel. Heat exchanger tubes shall be installed on the vest plate by means of swaged assembly, welded connections are not acceptable. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and also permit expansion and contraction of the tubes.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Heat exchanger shall have a ten (10) year extended warranty.
5. Furnace control shall be 12 (minimum):1 Modulating.
6. Shall be encased in a weather-tight metal housing with intake air vents. Large, metal lift-off door shall provide easy access to the enclosed vest plate, control circuitry, gas train, burner assembly and exhaust blower.
7. Shall have solid state controls permitting stand-along operation or control by building controllers.
8. Shall have fault sensors to provide fault conditions to building controls.

C. Heat-Exchanger Drain Pan Material: Stainless steel.

D. Venting Integral Combustion: Power vent gas blower with integral, motorized centrifugal fan interlocked with gas valve.

E. Safety Controls:

1. Gas Control Valve: Electronic modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.8 FILTERS

Unit shall have permanent metal filters located in the outdoor air intake and shall be accessibly for the exterior of the unit. 2” MERV 8 disposable pleated filters shall be provided in the supply air stream. 2” MERV 8” disposable pleated filters shall be provided in the supply final air stream and MERV 8 filters in the exhaust air stream.

1. Filter media installed during Construction: Minimum MERV 8 (or class F50
2. Filter media installed prior to occupancy: Minimum MERV 13 (or class F7)

2.9 ELECTRICAL POWER CONNECTIONS

A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.

B. Enclosure: NEMA 250, Type 4X mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key,

C. Wiring: Numbered and color-coded to match wiring diagram.

D. Wiring Location: Install factory wiring outside an enclosure in a raceway.

E. Power Interface: Field power interface shall be to wire lugs.

F. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

G. Factory-Mounted, Overcurrent-Protection Service: For each motor.

H. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

I. Controls: Factory wire unit-mounted controls where indicated. Provide terminal strip for field mounted controls by the ATC Contractor. Coordinate all refrigeration, heat, heat wheel controls by the manufacturer with the ATC contractor for a fully turnkey installation.

J. Lights: Factory wire unit-mounted lights.

K. Control Relays: Auxiliary and adjustable time-delay relays.

L. Phase and brownout protection. Unit shall have a factory-installed phase monitor to detect electric supply phase loss and voltage brown-out conditions. Upon detection of a fault, the monitor shall disconnect supply voltage to all motors.

2.10 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC."

B. Control Valves: Comply with requirements in Section 230900 "Instrumentation and Control for HVAC."

C. Control Wiring: Factory wire connection for controls' power supply.

D. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.

E. Unit Controls:

1. The unit shall be constructed so that it can be operated as a heating and cooling system controlled by a Building Management System (BMS). The unit's refrigeration and safety controls shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to the building DDC system. Provide a factory mounted terminal strip for field mounting the ATC DDC controller by the building ATC Contractor. Coordinate requirements.
2. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

F. Control Dampers:

1. Damper Location: Factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification.
2. Damper Leakage: Comply with requirements in AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. (33 L/s per sq. m) at a static-pressure differential of 4.0 inches water column (1000 Pa) when a torque of 5 inch pounds per sq. ft. (30.1 Newton meters per sq. m) is applied to the damper jackshaft.
3. Damper Rating: Rated for close-off pressure equal to the fan shutoff pressure.
4. Damper Label: Bear the AMCA seal for both air leakage and performance.
5. Blade Configuration: Unless otherwise indicated, use parallel blade configuration for two-position control and equipment isolation service and use modulating control when mixing two airstreams. For other applications, use an opposed-blade configuration.
6. Damper Frame Material: Extruded aluminum.
7. Blade Type: Hollow-shaped airfoil.
8. Blade Material: Extruded aluminum.
9. Maximum Blade Width: 6 inches (150 mm).
10. Maximum Blade Length: 48 inches (1200 mm).
11. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression-type seals.
12. Bearings: Thrust bearings for vertical blade axles.
13. Airflow Measurement:

    a. Monitoring System: Complete and functioning system of airflow monitoring as an integral part of the damper assembly where indicated.
    b. Remote Monitoring Signal: 0-10 volt or 4-20 mA scaled signal.
    c. Accuracy of flow measurement: Within 5 percent of the actual flow rate between the range of the scheduled minimum and maximum airflow. For units with a large

range between minimum and maximum airflow, configure the damper sections and flow measurement assembly as necessary to comply with accuracy.

d. Straightening Device: Integral to the flow measurement assembly if required to achieve the specified accuracy as installed.

e. Flow measuring device: Suitable for operation in untreated and unfiltered outdoor air. If necessary, include temperature and altitude compensation and correction to maintain the accuracy.

G. Damper Operators:

1. Factory-installed electric operator for each damper assembly with one operator for each damper assembly mounted to the damper frame.
2. Operator capable of shutoff against fan pressure and able to operate the damper with sufficient reserve power to achieve smooth modulating action and proper speed of response at the velocity and pressure conditions to which the damper is subjected.
3. Maximum Operating Time: Open or close damper 90 degrees in 60 90 <Insert value> seconds.
4. Adjustable Stops: For both maximum and minimum positions.
5. Position Indicator and Graduated Scale: Factory installed on each actuator with words "OPEN" and "CLOSED," or similar identification, at travel limits.
6. Spring-return operator to fail-safe; either closed or open as required by application.
7. Operator Type: Direct coupled, designed for minimum 60,000 full-stroke cycles at rated torque.
8. Position feedback Signal: For remote monitoring of damper position.
9. Coupling: V-bolt and V-shaped, toothed cradle.
10. Circuitry: Electronic overload or digital rotation-sensing circuitry.

H. Packaged DX Control and Diagnostics: The Packaged DX system shall be controlled by an onboard digital controller (DDC) that indicates both owner-supplied settings and fault conditions that may occur. The DDC shall be programmed to indicate the following faults:

1. Global alarm condition (active when there is at least one alarm).
2. Supply Air Proving alarm.
3. Dirty Filter Alarm.
4. Compressor Trip Alarm.
5. Compressor Locked out Alarm.
6. Supply Air Temperature Low Limit Alarm.
   a. Sensor #1 Out of Range (outside air temperature)
   b. Sensor #2 Out of Range (supply air temperature)
   c. Sensor #3 Out of Range (cold coil leaving air temperature)

I. Refrigeration System Controls:

1. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb (65 kJ/kg) of dry air or outdoor-air temperature is less than 60 deg F (15 deg C).
2. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F (15 deg C).
3. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 50 percent.

J. Smoke Duct Detectors: Smoke detector installed in supply and return air shall be furnished by the Fire Alarm Contractor, Installed by the mechanical contractor, hard wired to the unit by the ATC Contractor and wired to the fire alarm contractor by the electrical contractor.

K. DDC Temperature Control: Provide all basic refrigeration and safety controls and terminal strip for field mounted ATC controls. Coordinate all requirements for a fully turnkey installation. Integrate all manufacturers' controls into the building ATC system through BacNet.

L. BAS Interface: Terminal strip for field mounted ATC Controls

1. ASHRAE 135 (BACnet) communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

2.11 ENERGY RECOVERY WHEEL

A. Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework (designed to produce laminar air flow through the wheel), an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt with a five year warranty. The wheel media shall be a polymer film matrix in a stainless steel framework and be comprised of individual segments that are removable for servicing. Non-segmented energy wheels are not acceptable. Molecular sieve desiccant (silica gel is prohibited) shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.

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 piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.

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

3.2 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

C. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."

D. Install separate devices furnished by manufacturer and not factory installed.

E. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

F. Install drain pipes from unit drain pans to storm water drain.

1. Drain Piping: Drawn-temper copper water tubing complying with ASTM B 88, Type L with soldered joints.

G. Pipe Size: Minimum same size as condensate drain pan connection. Coordinate and install all indirect gas furnace combustion air and flue exhaust based one the manufacturer's recommendations.

H. Coordinate and install all refrigerant piping (approximately 7 pipes per unit) with the Air Cooled Condensing Unit. Provide all manufacturers recommended refrigerant piping accessories, devices and controls to maintain the warranty and sequence of operation.

I. Provide all devices and controls for a modulating hot gas reheat dehumidification system that can be controlled to maintain the desired supply air set point which is controlled through the ATC system.

J. Provide all basic refrigeration controls, safeties etc. and a terminal strip for field mounting controls by the ATC Contractor. All controls work shall be coordinated between the unit manufacture and the ATC contractor for a fully turnkey installation. All basic controls by the unit manufacturer shall be Bacnet type and be integrated for monitoring purposes through the Building ATC system for alarms etc.

K. Provide matching remote Air Cooled Condensing Units by the AHU/DOAS unit manufacturer to match the scheduled performance data for a fully turnkey installation and common refrigeration system 5 year warranty including parts, labor and loss of refrigerant.

3.3 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Gas Piping Connections:

1. Comply with requirements in Section "Facility Natural-Gas Piping."
2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
3. Install AGA-approved flexible connectors.

C. Duct Connections:

1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

D. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.

1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-limit heat exchanger.
    b. Alarms.

5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:

    a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
    b. Cooling coil entering-air, dry- and wet-bulb temperatures.
    c. Condenser coil entering-air dry-bulb temperature.
    d. Condenser coil leaving-air dry-bulb temperature.

7. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.

21. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air flow.
    c. Outdoor-air flow.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

- END OF SECTION 23 74 33 -

SECTION 23 81 26
SPLIT SYSTEM AIR CONDITIONERS

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 QUALITY ASSURANCE

A. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

D. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the proposed ASHRAE 90.1 efficiency requirements for split systems. Efficiency shall be published in accordance with the DOE alternative test procedure, which is based on the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standards 340/360, 1230 and ISO Standard 13256-1.

E. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

1.3 DELIVERY, STORAGE AND HANDLING

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

1.4 CONTROLS

A. The control system shall consist of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. All controllers shall be dual setpoint type via BACnet A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface. Provide interface with the county energy management system.

B. System controls and control components shall be installed in accordance with the manufacturer's written installation instructions.

C. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.

D. System shall provide direct and reverse-acting on and off algorithms based on an input condition or group conditions to cycle a binary output or multiple binary outputs.

E. System shall be capable of email generation for remote alarm annunciation.

F. Control system start-up shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in Daiken, LG or Mitsubishi controls system configuration and operation. The representative shall provide proof of certification for Mitsubishi CMCN Essentials Training and/or CMCN Hands-On Training indicating successful completion of no more than two (2) years prior to system installation or similar per manufacturer. This certification shall be included as part of the equipment and/or controls submittals. This service shall be equipment and system count dependent and shall be a minimum of one (1) eight hour period to be completed during normal working hours. Refer to training in Section 230500 for additional requirements.

G. All controls and control devices shall be hard wired (i.e. no wireless).

1.5 PIPING

A. Only ACR copper piping shall be utilized.

B. All brazing shall be done with dry nitrogen.

C. Pressure test refrigerant piping with dry nitrogen at 500 PSI for a minimum of two (2) hours. Pressure test shall be witnessed by the owner.

D. Triple evacuation shall be performed down to 500 microns minimum with electronic micron gauge.

E. Comply with more stringent manufacture requirements.

F. All refrigerant piping connections shall be seat type (i.e. no flared connections).

1.6 WARRANTY

A. The units shall be covered by the manufacturer's warranty for a period of ten (10) years from date of substantial completion. Final payment is contingent upon the Owner receiving the manufactures acceptance of the warranty report.

If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

This warranty shall not include labor.

B. Manufacturer shall have a minimum of five (5) years of HVAC experience 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of design shall be Daiken or as approved equal of the following listed manufacturers
   a. Mitsubishi
   b. LG

2.2 OUTDOOR UNIT

A. General:
   1. Outdoor unit shall have a sound rating no higher than 60 dB(A) individually or 64 dB(A) twinned. Units shall have a sound rating no higher than 50 dB(A) individually or 53 dB(A) twinned while in night mode operation. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.
   2. Both refrigerant lines from the outdoor unit to the indoor unit shall be insulated in accordance with the installation manual.
   3. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.
   4. The outdoor unit shall be capable of operating in heating mode down to -4°F ambient temperatures or cooling mode down to 23°F ambient temperatures, without additional low ambient controls. If an alternate manufacturer is selected any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.
   5. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
   6. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend “no or reduced heating” periods shall not be allowed.
   7. For split systems provide low ambient cooling down to 0°F.
   8. Provide wind baffles where applicable.
   9. Maximum diversity shall be 150% based on maximum fan coil unit connection capacity at high speed

B. Unit Cabinet:

   1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished.

C. Fan:

   1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.

   2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.

   3. All fan motors shall be mounted for quiet operation.

4. All fans shall be provided with a raised guard to prevent contact with moving parts.

5. The outdoor unit shall have vertical discharge airflow.

D. Refrigerant

1. R410A refrigerant shall be required for outdoor unit systems.

2. Polyolester (POE) oil 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 for approval at least two weeks prior to bidding.

E. Coil:

1. The outdoor 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 metal guard.

4. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.

5. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

F. Compressor:

1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.

2. A crankcase heater(s) shall be factory mounted on the compressor(s).

3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 19%-5% of rated capacity, depending upon unit size.

4. The compressor will be equipped with an internal thermal overload.

5. The compressor shall be mounted to avoid the transmission of vibration.

6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.

G. Controls:

1. The outdoor unit shall have the capability of varying its capacity for each refrigerant system based on system demand.

H. Electrical:

1. The outdoor unit electrical power shall be 208/230 volts, 3-phase, 60 hertz.
2. The outdoor unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz), 207-253V (230V/60Hz).
3. The outdoor unit shall be controlled by integral microprocessors.
4. The control circuit between the indoor units, and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.3 INDOOR UNIT (5 TONS (18kW) OR LESS)

A. Concealed Evaporator-Fan Components:

a. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
b. Insulation: Faced, glass-fiber duct liner.
c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
d. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.
e. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
f. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
g. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Wiring Terminations: Connect motor to chassis wiring with plug connection.

h. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
i. Filters: Permanent, cleanable.
j. Condensate Drain Pans:

    a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
        2) Depth: A minimum of 2 inches (50 mm) deep.

    b. Single-wall, plastic, galvanized, or stainless steel sheet.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.

        1) Minimum Connection Size: NPS 1 (DN 25).

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
f. Furnish with condensate overflow switch that will shut-down unit should an overflow condition occur.

B. Wall-Mounted, Evaporator-Fan Components:

a. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
b. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
c. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
d. Fan: Direct drive, centrifugal.
e. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
f. Mount unit-mounted disconnect switches on exterior of unit.

f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
g. Condensate Drain Pans:

a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 1 inch (25 mm) deep.

b. Single-wall, plastic, galvanized, or stainless-steel sheet.
c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.

1) Minimum Connection Size: NPS 1 (DN 25).

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
e. Furnish with condensate overflow switch that will shut-down unit should an overflow condition occur.

h. Air Filtration Section:

a. General Requirements for Air Filtration Section:

1) Comply with NFPA 90A.
2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Disposable Panel Filters:

1) Factory-fabricated, viscous-coated, flat-panel type.
2) Thickness: 1 inch (25 mm).

2.4 OUTDOOR UNITS

A. Air-Cooled, Compressor-Condenser Components:

a. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
b. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Scroll.
b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
c. Refrigerant Charge: R-410A.
d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.

c. Fan: Aluminum-propeller type, directly connected to motor.
d. Motor: Permanently lubricated, with integral thermal-overload protection.
e. Low Ambient Kit: Permits operation down to 0 deg F.
f. Mounting Base: Polyethylene.

2.5 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

D. Drain Hose: For condensate.

E. Provide shut off valves for each refrigerant circuit to a fan coil unit

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base that is 4 inches (100 mm) larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

E. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

G. Install system controller and interlock all indoor and water-cooled units.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Install isolation valves on all pipes between water-cooled unit and branch selector boxes.

D. Install isolation valves on pipes at each indoor unit.

3.3 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.

   a. 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. Tests and Inspections:

   a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
d. Verify fluid flow rates.
e. Test all fluid flow switches.

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

a. Complete installation and startup checks according to manufacturer's written instructions.

b. Verify proper BACnet integration and web-based controller functionality.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

- END OF SECTION 23 81 26 -

SECTION 23 81 29
VARIABLE-REFRIGERANT-FLOW HVAC 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 complete VRV/VRF HVAC system(s) including, but not limited to, delegated design and the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, concealed, ceiling-mounted units for ducting.
2. Indoor, recessed, ceiling-mounted units.
3. Heat recovery control units.
4. System controls.
5. System refrigerant and oil.
6. System condensate drain piping.
7. System refrigerant piping.
8. Metal hangers and supports.
9. Metal framing systems.
10. Fastener systems.
11. Pipe stands.
12. Miscellaneous support materials.
13. Piping and tubing insulation.
14. System control cable and raceways.

1.3 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.

C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRV/VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

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. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.

H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.

I. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 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 indoor and outdoor units and for HRCUs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit and HRCU control.
6. Include description of control software features.
7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
8. Include refrigerant type and data sheets showing compliance with requirements indicated.
9. For system design software.
10. Indicate location and type of service access.

B. Shop Drawings: For VRV/VRF HVAC systems.

1. Include plans, elevations, sections, and mounting 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. 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.

4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

D. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

E. Submit all test procedures required by the manufacturer and the commissioning agent. Include when they are to occur during the installation process.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and 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 floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Service access panels.

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

a. Retain copies of Installer certificates on-site and make available on request.

2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

C. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranties: For manufacturer's warranties.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

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:

a. Two set(s) for each unit with replaceable filters.
b. Two set(s) for each unit type and unique size of washable filters.

2. Controllers for Indoor Units: One for each unique controller type installed.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Nationally recognized manufacturer of VRV/VRF HVAC systems and products.
2. Shipped VRV/VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. VRV/VRF HVAC systems and products that have been successfully tested and in use on at least five completed projects.
4. Having complete published catalog literature, installation, and 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. Product manufacturing, testing, and quality control.
d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRV/VRF HVAC system manufacturer.
2. In-place facility located within 50 miles of Project.
3. Demonstrated past experience with products being installed for period within five consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope, and value.

   a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

   a. Demonstrated past experience with products being installed for period within five consecutive years before time of bid.
   b. Demonstrated past experience on five projects of similar complexity, scope, and value.

5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

D. Mockups: Build mockups to set quality standards for materials and execution.

1. Build mockups to show a finished installation for each of the following applications:

   a. For each different indoor unit type with exposed surfaces viewable by occupants.

2. Mockups shall be operational.
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.

E. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures.
b. Faulty operation.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts, Including Controls and Refrigerant: Five year(s) from date of Substantial Completion.
c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Base Bid: Basis of design shall be Daiken with iTouch control system or as approved equal of the following listed manufacturers
1. Mitsubishi
2. LG

B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. HRCUs.
4. Refrigerant isolation valves.
5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRV/VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Three or Two-pipe system design.
2. System(s) operation, heat pump or heat recovery as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

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. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRV/VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.

   a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
   b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
3. System Refrigerant Piping and Tubing:

a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

4. System Controls:

a. Network arrangement.
b. Network interface with other building systems.
c. Product selection.
d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch (450-mm) reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

1. Future changes to system(s) indicated on Drawings.
2. Each branch circuit shall accommodate addition of one indoor unit(s) with unit capacity equal to average indoor unit connected to the branch circuit.
3. Each branch circuit shall accommodate deletion of one indoor unit(s) with unit capacity equal to average indoor unit connected to the branch circuit.

E. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than 60 percent.
2. Not more than 150 percent.
3. Range acceptable to manufacturer.

G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

I. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

a. Design equipment and supports to withstand wind loads of governing code and ASCE/SEI 7
b. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7
c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: See Drawings
3. Minimum System Operating Outdoor Temperature: See Drawings

J. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
2. Outdoor: Within ordinance of governing authorities.

K. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

L. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled[and -tested] complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.

2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
   d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7
3. Media:
   a. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Provide refrigerant shut off valves for each piping circuit to a VRV/VRF Fan Coil Unit.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

   a. Unit inlet air temperature.

b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:

a. Analog Inputs: Four for use in customizable control strategies.
b. Digital Inputs: Four for use in customizable control strategies.
c. Digital Outputs: Four for use in customizable control strategies.

5. Features and Functions:

a. Self-diagnostics.
b. Time delay.
c. Auto-restart.
d. External static pressure control.
e. Auto operation mode.
f. Manual operation mode.
g. Filter service notification.
h. Power consumption display.
i. Drain assembly high water level safety shutdown and notification.
j. Run test switch.

6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.5 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, to accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7
3. Media:
    a. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

    a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
    b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.

2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.

3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

K. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature Coil entering refrigerant temperature Coil leaving refrigerant temperature
4. Field-Customizable I/O Capability:

a. Analog Inputs: Four for use in customizable control strategies.
b. Digital Inputs: Four for use in customizable control strategies.
c. Digital Outputs: Four for use in customizable control strategies.

5. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification , run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.6 OUTDOOR, AIR-SOURCE HEAT RECOVERY AND HEAT PUMP UNITS:

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.

2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

   a. Coating with documented salt spray test performance of [1000] hours according ASTM B 117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

   a. High refrigerant pressure.
   b. Low oil level.
   c. High oil temperature.
   d. Thermal and overload.
   e. Voltage fluctuations.
   f. Phase failure and phase reversal.
   g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

   a. Casing: Aluminum, galvanized, or stainless steel.
   b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
   c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

   a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
   b. Single- or multiple-pass arrangement.
   c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

   a. Direct-drive arrangement.
   b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
   c. dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

   a. Refrigerant suction temperature.
   b. Refrigerant discharge temperature.
   c. Outdoor air temperature.
   d. Refrigerant high pressure.
   e. Refrigerant low pressure.
   f. Oil level.

4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode, night setback control, power consumption display, run test switch equalize run time between multiple same components.
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according ASTM B 117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.7 HEAT RECOVERY CONTROL UNITS (HRCUs)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

B. Cabinet:

1. Galvanized-steel construction.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:

1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.
2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.
3. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.
4. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.

5. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.

    a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: See above.
4. Features and Functions: Self-diagnostics, fuse protection, See above.
5. Communication: Network communication with indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.8 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a manufacturer-selected control network.
2. Network Communication Protocol: open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.

b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
c. Integration shall include control monitoring scheduling change of value notifications

4. Operator Interface:

a. Operators shall interface with system and unit controls through the following:

1) Operator interfaces integral to controllers.
2) Owner-furnished PC connected to central controller(s).
3) Web interface through web browser software.
4) Integration with Building Automation System.

b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:

1) On/off control.
2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: English Supports Imperial and Metric Temperature Units: Fahrenheit and Celsius.
10. Displays service notifications and error codes.
11. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
12. Monitors and displays cumulative operating time of indoor units.
13. Able to disable and enable operation of individual controllers for indoor units.
14. Information displayed on individual controllers shall also be available for display.
15. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.

    a. Include multiple interconnected controllers as required.

2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.
    b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English
4. Temperature Units: Fahrenheit and Celsius.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter"
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.

20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

E. Wireless Controllers for Indoor Units:

1. Wireless Communication:

a. Controller communicates to remote-mounted receiver that is wired to indoor unit(s).

1) Include receivers with wireless controllers as required to complete installation.
2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.

2. Controller Battery Life: Three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Multiple Language: English
5. Temperature Units: Fahrenheit and Celsius.
6. On/Off: Turns indoor unit on or off.
7. Hold: Hold operation settings until hold is released.
8. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
9. Temperature Display: 1-degree increments.
10. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments
11. Relative Humidity Display: 1 percent increments.
12. Relative Humidity Set-Point: Adjustable in 1 percent increments
13. Fan Speed Setting: Select between available options furnished with the unit.
14. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
15. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
16. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
17. Occupancy detection.
18. Service Notification Display: "Filter"
19. Service Run Tests: Limit use by service personnel to troubleshoot operation.
20. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
21. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
22. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

2.9 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRV/VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.10 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B 88, Type L (ASTM B 88M, Type B) or Type DWV according to ASTM B 306.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B 32, lead-free alloys, and water-flushable flux according to ASTM B 813.

C. CPVC plastic pipe according to ASTM F 441/F 441M, Schedule 40, with socket-type pipe fittings according to ASTM F 438 and solvent cement according to ASTM F 493.

D. PVC plastic pipe according to ASTM D 1785, Schedule 40, with socket-type pipe fittings according to ASTM D 2466 and solvent cement according to ASTM D 2564, primer according to ASTM F 656.

2.11 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

B. Refrigerant Piping:

1. Copper Tube: ASTM B 280, Type ACR
2. Wrought-Copper Fittings: ASME B16.22.
3. Brazing Filler Metals: AWS A5.8/A5.8M.

C. Refrigerant Tubing Kits:

1. Furnished by VRV/VRF HVAC system manufacturer.
2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
3. Standard one-piece length for connecting to indoor units.
4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
5. Factory Charge: Dehydrated air or nitrogen

D. Divided-Flow Specialty Fittings: Where required by VRV/VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

E. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.12 METAL HANGERS AND SUPPORTS

A. Copper Tube 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

B. Plastic Pipe Hangers:

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

2.13 FASTENER SYSTEMS

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

1. Indoor Applications: stainless steel.
2. Outdoor Applications: Stainless steel.

2.14 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 or more cadmium-plated-steel or stainless-steel, continuous-thread rods.

4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

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

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

2.15 MISCELLANEOUS SUPPORT MATERIALS

A. 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.

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

C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.16 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.

B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C 534, Type I for tubular materials.
b. Indoors: 1 inch (25 mm) thick.
c. Outdoors: 1 inch (25 mm) thick.

2. Field-Applied Jacket:

a. Concealed: None required.
b. Indoors, Exposed to View: PVC, color selected by Architect, 20 mils (0.5 mm) thick
c. Outdoors, Exposed to View: Aluminum, embossed, 0.020 inch (0.51 mm) thick

C. Refrigerant Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C 534, Type I for tubular materials.
b. Indoors: 1 inch (25 mm) thick.
c. Outdoors: 1 inch (25 mm) thick.

2. Field-Applied Jacket:

a. Concealed: None required.
b. Indoors, Exposed to View: PVC, color selected by Architect, 20 mils (0.5 mm) thick
c. Outdoors, Exposed to View: Aluminum, embossed, 0.020 inch (0.51 mm) thick

D. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: Aluminum.

2.17 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

a. Flame Travel Distance: 60 inches (1520 mm) or less.
b. Peak Optical Smoke Density: 0.5 or less.
c. Average Optical Smoke Density: 0.15 or less.

2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.

a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
b. PVC insulation.
c. Braided or foil shielded.
d. PVC jacket.
e. Flame Resistance: Comply with UL 1685.

2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
b. PVC insulation.
c. Braided or foil shielded.
d. PVC jacket.

e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
f. Flame Resistance: Comply with NFPA 262.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.

a. Paired, one pair, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
b. PVC insulation.
c. Unshielded.
d. PVC jacket.
e. Flame Resistance: Comply with UL 1685.

2. Plenum-Rated Cable: NFPA 70, Type CMP.

a. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
b. Fluorinated ethylene propylene insulation.
c. Unshielded.
d. Fluorinated ethylene propylene jacket.
e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
f. Flame Resistance: NFPA 262.

D. Ethernet Network Cabling: TIA-568-C.2 Category 6a cable with RJ-45 connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
2. Conductors: 100-ohm, 23 AWG solid copper.
3. Shielding: Shielded twisted pairs (FTP)
4. Cable Rating: By application.
5. Jacket: White thermoplastic.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.18 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

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 products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

1. Loose components shall be installed by manufacturer's service representative

C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch (10 mm).

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch (13 mm)

H. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

I. Floor-mounted units located in mechanical rooms.

J. Install floor-mounted units on support structure indicated on Drawings.

K. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

L. Attachment: Install hardware for proper attachment to supported equipment.

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

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

H. Install fittings for changes in direction and branch connections.

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.
    c. Governing codes.
    d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than two percent.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.

2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet (1.5 m). Minimum rod size, 1/4 inch (6.4 mm).
3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

C. Select system components with pressure rating equal to or greater than system operating pressure.

D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

F. Install refrigerant piping and tubing in protective conduit where installed belowground.

G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

I. When brazing, remove or protect components that could be damaged by heat. Nitrogen flush during brazing, to avoid the development of oxidized film which could damage valves and compressors.

J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRV/VRF HVAC system manufacturer.

K. Provide ball type isolation valves for each Fan Coil Unit circuit piping such that each unit can be isolated without affecting operation of the rest of the connected system.

L. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

A. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

B. 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.

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

D. Comply with MFMA-103 for metal framing system selections and applications that are not specified.

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

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 Section 077200 "Roof Accessories" for curbs.

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

H. 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.

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

J. Install building attachments within concrete slabs or attach to structural steel.

1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

L. 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.

M. Piping and Tubing Insulation:

1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
2. 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.

N. Horizontal-Piping Hangers and Supports: 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. 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.
3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu if individual clevis hangers.
5. Pipe stands for horizontal pipes located outdoors.
6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

O. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:

1. Sizes through NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

P. Plastic Pipe Hanger and Support Spacing:

1. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
2. Maximum spacing, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).

Q. Vertical-Piping Clamps: Install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.

R. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 feet (1.5 m)

S. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.

T. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.

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

V. Trim excess length of continuous-thread hanger and support rods to 1 inch (25 mm)

W. Hanger-Rod Attachments: 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. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

X. Building Attachments: 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).

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.

3.9 INSTALLATION OF PIPING AND TUBING 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. Installation to maintain a continuous vapor barrier.

B. 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.

C. 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 unavailable, 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. 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.

D. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

E. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.10 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.

B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."

C. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."

D. Comply with requirements for air diffusers specified in Section 233713 “Diffusers, Registers and Grilles."

E. Comply with requirements for registers and grilles specified in Section 233713 “Diffusers, Registers and Grilles."

3.11 ELECTRICAL INSTALLATION

A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.

B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.

1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.

C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch (13 mm) high.
2. Locate nameplate or label where easily visible.

G. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.

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. Outlet boxes for cables shall be no smaller than 4 inches (102 mm) square by [1-1/2 inches (38 mm)] [2-1/8 inches (53 mm)] deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
3. Flexible metal conduit shall not be used.

H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

I. Install manufactured conduit sweeps and long-radius elbows if possible.

J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.12 SOFTWARE

A. Cybersecurity:

1. Software:

a. Coordinate security requirements with IT department
b. Ensure that latest stable software release is installed and properly operating.
c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

a. Coordinate location and access requirements with IT department
b. Disable dual network connections.

3.13 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:

a. Within equipment and associated control enclosures.
b. In accessible ceiling spaces where open cable installation method may be used.
c. In gypsum board partitions where cable may be enclosed within wall cavity.

2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
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 and shall be continuous from terminal to terminal. Do not splice cable.
5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. 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.
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 ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. 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. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch (13 mm) at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 30 inches (760 mm) apart.
2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.14 FIRESTOPPING

A. Comply with requirements in Division 7 "Joint Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.15 GROUNDING INSTALLATION

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.16 IDENTIFICATION

A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."

B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.17 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

1. Field service shall be performed by a factory-trained of VRV/VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.

2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.

    a. First Visit: Kick-off meeting.
    b. Second Visit: At approximately 25 percent completion of system(s).
    c. Third Visit: At approximately 50 percent completion of system(s).
    d. Fourth Visit: At approximately 75 percent completion of system(s).
    e. Fifth Visit: Final inspection before system startup.

3. Kick-off Meeting:

    a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
    b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
    c. Meeting shall cover the following as a minimum requirement:

        1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRV/VRF HVAC systems.
        2) Manufacturer's installation requirements specific to systems being installed.
        3) Review of all relevant VRV/VRF HVAC system submittals, including delegated-design submittals.
        4) Required field activities related installation of VRV/VRF HVAC system.
        5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, commissioning agent, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:

    a. Meet with VRV/VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
    b. Offer technical support to Installer and related trades as related to VRV/VRF system(s) being installed.
    c. Review progress of VRV/VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
    d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
    e. Issue a report for each visit, documenting the visit.

        1) Report to include name and contact information of individual making the visit.
        2) Date(s) and time frames while on-site.
        3) Names and contact information of people meeting with while on-site.
        4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
d. Inspection reports for indoor units shall include, but not be limited to, the following:

    1) Unit designation on Drawings.
    2) Manufacturer model number.
    3) Serial number.
    4) Network address, if applicable.
    5) Each equipment setting.
    6) Mounting, supports, and restraints properly installed.
    7) Proper service clearance provided.
    8) Wiring and power connections correct.
    9) Line-voltage reading(s) within acceptable range.
    10) Wiring and controls connections correct.
    11) Low-voltage reading(s) within an acceptable range.
    12) Controller type and model controlling unit.
    13) Controller location.
    14) Temperature settings and readings within an acceptable range.
    15) Humidity settings and readings within an acceptable range.
    16) Condensate removal acceptable.
    17) Fan settings and readings within an acceptable range.
    18) Unit airflow direction within an acceptable range.
    19) If applicable, fan external static pressure setting.
    20) Filter type and condition acceptable.
    21) Noise level within an acceptable range.
    22) Refrigerant piping properly connected and insulated.
    23) Condensate drain piping properly connected and insulated.
    24) If applicable, ductwork properly connected.
    25) If applicable, external interlocks properly connected.
    26) Remarks.

e. Inspection reports for outdoor units shall include, but not be limited to, the following:

    1) Unit designation on Drawings.
    2) Manufacturer model number.
    3) Serial number.
    4) Network address, if applicable.
    5) Each equipment setting.
    6) Mounting, supports, and restraints properly installed.
    7) Proper service clearance provided.
    8) Wiring and power connections correct.
    9) Line-voltage reading(s) within acceptable range.
    10) Wiring and controls connections correct.
    11) Low-voltage reading(s) within an acceptable range.
    12) Condensate removal acceptable.
    13) Noise level within an acceptable range.
    14) Refrigerant piping properly connected and insulated.
    15) Condensate drain piping properly connected and insulated.

16) Remarks.

f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
g. Installer shall correct observed deficiencies found by the inspection.
h. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
i. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
j. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRV/VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRV/VRF HVAC system operating pressure, but not less than 600 psig (4137 kPa) using dry nitrogen
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:

a. Name of person starting test, company name, phone number, and e-mail address.
b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
c. Detailed description of extent of tubing tested.
d. Date and time at start of test.
e. Test pressure at start of test.
f. Outdoor temperature at start of test.
g. Name of person ending test, company name, phone number, and e-mail address.
h. Date and time at end of test.
i. Test pressure at end of test.
j. Outdoor temperature at end of test.
k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRV/VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRV/VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.18 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be a factory-trained service representative of VRV/VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).

2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit[, HRCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.19 ADJUSTING

A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRV/VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.20 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.21 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are manufacturer's authorized service representative. Include four service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.22 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.23 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

B. Instructor:

1. Instructor shall be factory trained and certified by VRV/VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
2. Instructor's credentials shall be submitted for review by Architect before scheduling training.
3. Instructor(s) primary job responsibility shall be Owner training.
4. Instructor(s) shall have not less than three years of training experience with VRV/VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.

C. Schedule and Duration:

1. Schedule training with Owner at least 20 business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one hour lunch period and 15 minute break after every two hours of training.
5. Perform not less than eight total hours of training.

D. Location: Owner shall provide a suitable on-site location to host classroom training.

E. Training Attendees: Assume three people.

F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.

G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.

H. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

I. Acceptance: Obtain Architect written acceptance that training is complete and requirements indicated have been satisfied.

- END OF SECTION 23 81 29 -

SECTION 23 82 36
FINNED-TUBE RADIATION HEATERS

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 electric baseboard radiation 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 and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of integral controls.
6. Include enclosure joints, corner pieces, access doors, and other accessories.
7. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which finned-tube radiation heaters will be attached.
2. Method of attaching finned-tube radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 ELECTRIC BASEBOARD RADIATION HEATERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Runtel Radiators EB3 Series or equal.

B. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.

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.

C. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.

D. Enclosures: Custom color powder coated electric panel radiator – baseboard style, low surface temperature type.

E. Unit Controls by ATC Contractor: Coordinate interface/interlock requirements.

F. Accessories:

1. Filler sections without a heating element matching the adjacent enclosure.

2.2 ELECTRIC FINNED-TUBE RADIATION HEATERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Markel 9300 Series Draft Barrier Heater or comparable product by one of the following:

1. Berko; Marley Engineered Products.
2. Chromalox.
3. Indeeco.
4. Marley Engineered Products.
5. Qmark; Marley Engineered Products.

B. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.

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.

C. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.

D. Rust-Resistant Enclosure: 12 gauge extruded 6063 aluminum heat treated to T5 hardness.

E. Wall-Mounted Back Panel: Minimum 12 gauge finished back.

F. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel shall be solid panel matching front panel.

G. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.

H. Finish: Baked-enamel or epoxy finish in manufacturer's custom color as selected by Architect.

I. Enclosure Style: Flat top.

1. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

   a. Mill-finish aluminum.

2. Top Front Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

   a. Mill-finish aluminum.

J. Unit Controls: Provided by the ATC Contractor. Coordinate interlock requirements.

K. Accessories: Integral disconnect switch, filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive finned-tube radiation 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 installation of finned-tube radiation heaters.

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

3.2 BASEBOARD RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

3.3 FINNED-TUBE RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

3.4 CONNECTIONS

A. Install temperature sensors and controls as required by Section 230900 "Instrumentation and Control for HVAC."

B. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

C. Ground electric finned-tube radiation heaters according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

- END OF SECTION 23 82 36 -

SECTION 23 82 39.13
CABINET UNIT 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 cabinet unit heaters with centrifugal fans and electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. 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 location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

D. Samples: For each exposed product and for each color and texture specified.

E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

F. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, 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. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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. Cabinet Unit-Heater Filters: Furnish two (2) spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Markel 6300 Series or comparable product by one of the following:

1. Berko; Marley Engineered Products.

2. Chromalox, Inc.
3. Indeeco.
4. Marley Engineered Products.
5. QMark; Marley Engineered Products.

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

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 2021.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 CABINETS

A. Material: Steel with baked-enamel or powder coated epoxy finish with manufacturer's custom paint, in color selected by Architect.

1. Removable front panel for access and grilles shall be easily convertible to any air flow configuration. Provide duct collars where ducted.

2.5 FILTERS

A. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV 5.

2.6 COILS

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

2.7 CONTROLS

A. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

C. Basic Unit Controls:

1. Wall-mounted temperature sensor by ATC Contractor for interface to EMS.

D. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.8 CAPACITIES AND CHARACTERISTICS: Refer to drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit 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 unit-heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC.

D. Install wall-mounted thermostats/temperature sensors 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.

E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

B. Comply with safety requirements in UL 1995.

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."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

- END OF SECTION 23 82 39.13 -

SECTION 23 82 39.16
PROPELLER UNIT 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 propeller unit heaters with electric-resistance heating coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.4 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 location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, 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. Suspended ceiling components.
2. Structural members to which propeller unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

B. Seismic Qualification Data: Submit certification that propeller unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." 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. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For propeller 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 of the following:
1. Modine.
2. Trane.
3. Vulcan.
4. Sterling.
5. McQuay International.

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

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 2021.

D. Comply with UL 823.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 HOUSINGS

A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.5 COILS

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). 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.

2.6 FAN AND MOTOR

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: Permanently lubricated, open drip-proof, multispeed, or variable speed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.7 CONTROLS

A. Control Devices:

1. Unit-mounted, variable fan-speed switch.
2. Wall-mounted thermostat.

2.8 CAPACITIES AND CHARACTERISTICS (Refer to Drawings)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

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

3.2 INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers [spring hangers. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

A. Comply with safety requirements in UL 1995.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

- END OF SECTION 23 82 39.16 -

SECTION 26 05 01
GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 GENERAL

A. Provide all labor, materials, equipment and services necessary for and incidental to the complete installation and operation of all electrical work.

B. All work under this Division is subject to the General Conditions and Special Requirements for the entire contract.

C. Unless otherwise specified, all shop drawings and submissions required under Division 26 shall be made to, and acceptances and approvals made by, the ENGINEER.

D. Conform to the requirements of all rules, regulations, and codes of local, state, and federal authorities having jurisdiction. Conform to the National Electrical Code and all NECA – National Electrical Installation Standards (NEIS).

E. Perform the work in a first-class, substantial, and workmanlike manner. Any materials installed which do not present an orderly and neat workmanlike appearance shall be removed and replaced when so directed by the Engineer, at the Contractor's expense.

F. Coordinate the work of all trades.

G. Arrange conduit, wiring, equipment, and other work generally as shown, providing proper clearances and access. Carefully examine all contract drawings and fit the work in each location without substantial alteration. Where departures are proposed because of field conditions or other causes, prepare and submit detailed drawings for approval in accordance with “Submittals” specified below. The right is reserved to make reasonable changes in location of equipment, conduit, and wiring up to the time of rough-in or fabrication.

H. The contract drawings are generally diagrammatic and all offsets, bends, fittings, and accessories are not necessarily shown. Provide all such items as may be required to fit the work to the conditions.

I. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in a first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the Contract Documents.

J. The Contractor shall provide other work and services not otherwise included in the Contract Documents that are customarily forwarded in accordance with generally-accepted construction practices.

1.2 PERMITS, INSPECTIONS, AND FEES:

1. The Contractor shall obtain and pay for all charges and fees, and deliver all permits, licenses, certificates of inspection, etc., required by the authorities having jurisdiction. Deliver inspection, approval, and other certificates to the Owner prior to final acceptance of the work.

B. File necessary plans, prepare documents, give proper notices, and obtain necessary approvals.

C. Permits and fees shall comply with the General Requirements of the Specification.

D. The Owner will pay for the building permit.

E. Notify Inspection Authorities to schedule inspections of work. All work shall be subject to field inspections.

F. Notify Architect in advance of scheduled inspections.

G. An electrical foreman, superintendent or other supervisor shall be in attendance for all scheduled inspections.

H. The Contractor shall provide an electrical certificate from an independent electrical inspection agency approved by the Owner and the State Fire Marshal. The Contractor shall submit certificate prior to final payment invoice. The Contractor shall pay all fees, including filing fees.

1.3 ELECTRICAL WORK UNDER OTHER DIVISIONS:

A. Mechanical Equipment and Systems

1. In general, power wiring and motor starting equipment for mechanical equipment and systems are furnished and installed under Electrical Division 26.

2. Certain mechanical units contain starters, contacts, transformers, fuses, wiring, etc., required for fans, pumps, etc., furnished with the equipment from the factory. When this equipment is supplied from the factory, the Contractor must supply power circuit(s) to the unit and a disconnecting means. Coordinate with Contractor so that one, and only one, set of starters, fuses, switches, etc., is provided and installed.

3. In general, control and interlock equipment for HVAC systems (including associated wiring, conduit, transformers, relays, contacts, etc.) is furnished under Mechanical Divisions. Contractor shall install and connect all such equipment as necessary.

4. Controls, wiring, conduit, transformers, etc., for smoke, fire, and motor-operated dampers are provided by Mechanical Contractor. Electrical shall install and connect all such equipment.

B. Architectural Equipment: In general, any electrically operated or controlled equipment furnished under architectural divisions shall be supplied with control wiring, transformers, contacts, etc. Contractor shall provide power circuits to such equipment and install all electrical control equipment related thereto.

C. Carefully review the contract documents and coordinate the electrical work under the various Divisions.

D. LEED Submittals: Comply with Section 018113.

1. EQ Credit 2: Low-Emitting Materials

a. For interior wet-applied adhesives, sealants, paints, coatings: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method v1.1–2010 and VOC content in g/L. Include volume of material applied per product.
b. For composite wood installed in building interior: Documentation indicating compliance with California Air Resources Board (CARB) Airborne Toxic Control Measure

(ATCM), Phase II for ultra-low-emitting formaldehyde (ULEF) resins or containing no added formaldehyde resins.

1.4 CONTRACTOR QUALIFICATION:

A. Any Contractor performing work under this Division shall be fully qualified and acceptable to the Engineer. Submit the following evidence for approval:

1. A list of not less than five (5) comparable projects that the Contractor completed.

2. Letters of reference from not less than three (3) registered professional engineers, contractors, or building owners, explaining Contractor proficiency, quality of work, or other attribute on projects of similar size or substance.

3. Local or State license.

4. Membership in trade or professional organization where required.

5. Copy of Master Electrician's License.

B. Contractor is any individual, partnership, corporation, or firm performing work by Contract or subcontract on this project.

C. Acceptance of a subcontractor will not relieve the Contractor of any contractual requirements or his responsibility to supervise and coordinate the various trades.

D. Supervisory Qualifications: The electrical work on the project shall be under the direct supervision of a licensed Master Electrician.

E. Qualifications of Installers:

1. For the actual fabrication, installation, and testing of the work, the Contractor shall use only thoroughly trained and experienced personnel who are completely familiar with the requirements of this work and with the installation recommendations of the manufacturers of the specified items.
2. The Electrical Installer shall utilize a full time project foreman in charge of all electrical work. This person shall be fully qualified and experienced in such work and shall be available, on site, at all times during Construction. All problems, questions, coordination, etc., relating to electrical work shall take place through this person to the Architect.

F. Qualifications of Video Tape Technician: For videotaping specified in "Operating Instructions", the Contractor shall provide the services of persons skilled in videotape production and editing.

1.5 FIRE SAFE MATERIALS:

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA, or ASTM Standards for Fire Safety with Smoke and Fire Hazard Rating not exceeding flame spread of 25 and smoke developed of 50.

1.6 REFERENCED STANDARDS, CODES, ORDINANCES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
IBC	International Building Code
CABO	Council of American Building Officials
FM	Factory Mutual
IEEE	Institute of Electrical and Electronics Engineers
MOSHA	Maryland Occupational Safety & Health Administration
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety & Health Administration
UL	Underwriters Laboratories

B. All electrical equipment and materials shall comply with the Codes and Standards listed in the latest edition of IEEE Standard 241, *Electric Power Systems in Commercial Buildings*, Chapter 1, Section 1.6, entitled "Codes and Standards".

C. Comply with all Codes applicable to the work:
   1. Bidders shall inform themselves of all local and state codes and regulations.
   2. In case of conflict between Contract Documents and governing Codes, the most stringent shall take precedence. Where, in any specific case, different sections of any applicable codes or when Drawings and Specifications specify different materials, methods of Construction, or other requirements, the most restrictive shall govern.
   3. Where Contract Documents exceed minimum Code requirements, and are permitted under the Code, the Contract Documents take precedence and shall govern.
   4. No extra payment will be allowed for work or changes required by local Code enforcement authorities.

D. Underwriters Laboratories Labels shall apply to all materials and devices, etc., except specified items not covered by existing UL Standards.

E. Conflicts with applicable regulations:
   1. Resolve at Contractor's expense.
   2. Prepare and submit details of alternate construction:
      a. Acceptable solution of conflict.

b. List of substitute materials:

For approval of inspecting authorities.
For approval of Engineer.

F. Comply with all NECA's National Electrical Installation Standards (NEIS), including NECA 1-2000 "Standard Practices for Good Workmanship in Electrical Contracting".

1.7 INTERPRETATION OF DOCUMENTS

A. Any discrepancies between Drawings, Specifications, Drawings and Specifications, or within Drawing and Specifications shall be promptly brought to the attention of the Owner during the bidding period. No allowance shall subsequently be made to the Contractor by reason of his failure to have brought said discrepancies to the attention of the Owner during the bidding period or of any error on the Contractor's part.

B. The locations of products shown on Drawings are approximate. The Contractor shall place the devices to eliminate all interference with above-ceiling ducts, piping, etc. Where any doubt exists, the exact location shall be determined by the Owner and Architect.

C. All general trades and existing conditions shall be checked before installing any outlets, power wiring, etc.

D. Equipment sizes shown on the Drawings are estimated. Before installing any wire or conduit, the Contractor shall obtain the exact equipment requirements and install wire, conduit, or other item of the correct size for the equipment actually installed. However, wire and conduit sizes shown on the Drawings shall be taken as a minimum and shall not be reduced without written approval from the Architect/Engineer.

E. Where variances occur between the drawings and specifications or within either document itself, the item or arrangement of better quality, greater quality, or higher cost shall be included in the Contract Price. The Engineer will decide on the item and manner in which the work shall be installed.

F. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions, and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange conduits, equipment, and other work generally as shown on the Contract Drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed Shop Drawings for approval in accordance with "submittals" specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

G. Work not specifically outlined, but reasonably incidental to the completion of the work, shall be included without additional compensation from the Owner.

1.8 CUTTING AND PATCHING

A. The cutting of walls, floors, partitions, etc., for the passage and/or accommodation of conduits, etc., the closing of superfluous openings and the removal of all debris caused by said work under this contract shall be performed by and at the expense of the Electrical Contractor.

B. No cutting of any structure or finishes shall be done until the condition requiring such cutting has been examined and approved by the Architect.

C. All surfaces disturbed as a result of such cutting shall be restored under this division to match original work and all materials used for any patching, mending or finishing must conform to the class of materials originally installed.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Material and equipment installed as a part of the permanent installation shall be new, unless otherwise indicated or specified, and shall be approved by the Underwriters' Laboratories, Inc., for installation in each particular case where standards have been established.

B. Where material or equipment is identified by proprietary name, model number, and/or manufacturer, furnish the named item or equivalent thereof, subject to acceptance.

C. Material submissions shall conform to requirements outlined in SUBMITTALS, REVIEW, AND ACCEPTANCE.

D. The suitability of named item only has been verified. Where more than one Manufacturer is named, only the first named Manufacturer has been verified as suitable alternate. Manufacturers and items other than the first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of alternate manufacturers for review. Provide a list company proposed and specified products and performance on the first page of the submittal. Failure to clearly identify differences will result in the submittal being returned as “Revise and Resubmit”. The Contractor, by providing other than the first named Manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation.

E. The Contractor shall only submit those manufacturers indicated in the Specification. Proposed manufacturers other than those indicated will not be considered unless the specific item indicates “or as approved equal”. Submit all data necessary to determine suitability of substituted items for approval. Failure to do so will result in a “Revise and Resubmit” response.

F. All items of equipment furnished shall have a service record of at least five (5) years.

G. Interior wet-applied adhesives, sealants, paints, and coatings: Comply with low-emitting requirements in Division 01 Section “Sustainable Design Requirements - LEED.”

H. Composite wood installed in building interior: Comply with California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM), Phase II for ultra-low-emitting formaldehyde (ULEF) resins or containing no added formaldehyde resins.

2.2 SUBSTITUTIONS

A. Substituted items or items other than those named shall be equal or better in quality and performance and must be suitable for the available space, required arrangement, and application. Submit any and all data necessary to determine the suitability of substituted items. The Contractor shall be responsible for correct application, placement, and installation of substituted equipment. Cost savings data shall also be submitted with submittal data for substituted items. Total cost savings or a per-unit saving to the Owner shall be clearly indicated. If a substituted item is accepted, all cost savings shall be returned to the Owner as a credit.

B. Substitutions will not be permitted for specific items of material or equipment where specifically indicated.

C. For substituted items, clearly list on the first page of the submittal all differences (i.e. paragraph-by-paragraph, performance differences, physical differences, etc.) between the specified item and the proposed item. The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements if differences have not been clearly indicated in the submittal.

D. Where the Contractor proposes to use an item of equipment or application other than that specified or detailed on the Drawings, which requires any redesign of the structure, partitions, foundation, HVAC, piping, wiring, or any other part of the mechanical, electrical, or architectural layout, all such redesign and all new drawings and detailing required thereafter shall be prepared by the Contractor at his own expense for review by the Owner representative, Architect and Engineer before any such work is implemented.

E. All Contractor-proposed changes and revisions shall be at the Contractor's risk and expense. The Contractor shall fully coordinate all revisions, substitutions and changes with other trades. The Contractor shall provide all necessary provisions, including HVAC, ventilation, foundations, access, etc., for a complete, code compliant, and fully functional installation.

F. Where the Contractor elects to submit a substitution for equipment or materials, he shall:

1. Submit Shop Drawings that show complete compliance to each statement or requirement of the Specifications.
2. Submit certified test data from an independent testing laboratory for each product.
3. Submit one complete working sample of the equipment or materials to be furnished. In cases involving large or heavy items of equipment, the Owner may waive the requirement to submit the sample.

G. Failure to comply with the above-required submissions shall constitute an automatic rejection of the substitution.

2.3 SUBMITTALS, REVIEW, AND ACCEPTANCE

A. General:

1. The equipment, material, installation, workmanship, arrangement of work, final instruction, and final documentation is subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Engineer to be in the best interest of the Owner. Submit for review in clear and legible form the following documents:
    a. Material and Equipment List
    b. Descriptive Data
    c. Shop Drawings
    d. Installation and Coordination Drawings
    e. Contractor As-Built Drawings
    f. Owner Instructions and Manuals
    g. Construction Phasing and Outage Schedule
2. Prepare all submittals specifically for this project and stamp each submittal in a form indicating that the documents have been Contractor reviewed, are complete, and are in compliance with the requirements of the plans and specifications. Each submittal item shall be clearly identified and numbered. Each submittal shall contain a complete schedule of Manufacturer's part numbers and quantity listings of all supplied components.

Each proposed item shall be highlighted and tagged with a star, an arrow, etc., including all options and accessories.

3. Coordinate the installation requirements and any mechanical requirements for the equipment submitted. Submittals will be reviewed for general compliance with design concept in accordance with the contract documents. The Contractor is responsible for the correctness of all submittals. Reviews will not verify dimensions, quantities, or other details.

4. Identify all submittals, indicating the intended application, location, or service of the submitted item. Refer to specification sections or paragraphs where applicable. Clearly indicate the exact type, model number, size, and special features of the proposed item. Clearly list on the first page of the Submittal all differences between the specified item and the proposed item. The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements, if differences have not been clearly indicated in the submittal. Submittals of a general nature will not be acceptable.

5. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Indicate all options used to meet the specifications. It is not the responsibility of the Engineer or Owner to make selections of factory options other than colors. Submittals lacking proper selection of factory options or special features required by the specification shall be RETURNED WITHOUT REVIEW.

6. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.

7. Documents of general form indicating options shall be clearly marked to show what is specifically proposed for this project.

8. Submittals NOT IN COMPLIANCE with the requirements of this section will be RETURNED WITHOUT REVIEW.

B. Material, Equipment, Manufacturer and Subcontractor List: Within 30 calendar days after the award of contract, submit a complete MATERIAL, EQUIPMENT, MANUFACTURER AND SUBCONTRACTOR LIST for preliminary review. List all proposed materials and equipment, the associated proposed Manufacturer, and any proposed subcontractors. After the receipt of reviewed Material and Equipment List, submit complete Shop Drawings for approval. List all materials and equipment, indicating manufacturer, type, class, model, curves, and other general identifying information. Submittals shall be specific for each building as contained in the individual building Specifications and Drawings.

C. Upon approval of the List of Materials, the Contractor shall prepare a complete Master Submittal Register, listing all products and materials that will be submitted for approval. Items shall be listed by referenced specification paragraph in ascending order. This master list shall be included with each submittal, updated to reflect the status of approval for each item, and shall highlight the items pertaining to the submittal. A suggested Submittal Register Format is shown below:

SUBMITTAL REGISTER					
Item/Material	Ref'd Spec. Paragraph	Specified or Substitute	Submittal Date	Status	Remarks

SUBMITTAL REGISTER					

D. No Shop Drawing Submittals will be considered for approval until the complete List of Subcontractors and the complete List of Materials/Manufacturers and Equipment have been approved.

E. Descriptive Data: After acceptance of the MATERIAL and EQUIPMENT LIST, submit additional DESCRIPTIVE DATA for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, installation instructions, and any other information necessary to indicate complete compliance with the contract documents. Where several ratings or sizes are shown or available, clearly indicate the exact size or rating relating to the particular device being proposed.

F. Submit complete descriptive data for all items. Data shall consist of Specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, specific electrical/wiring requirements and connections including control and interlock wiring, installation instructions, and any other information necessary to indicate complete compliance with the Contract Documents. Edit submittal data specifically for application to this project.

G. Shop Drawings shall be submitted and approved for all materials and equipment prior to installation. If any material and/or equipment is installed prior to receipt by the Contractor of approved Shop Drawings, the Contractor is liable for its replacement at no additional cost to the Owner.

H. Data submitted shall include information on all materials and equipment to demonstrate compliance with the Contract Drawings and Specifications. Where installation procedures or any part thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendations prior to installation. Installation of the item shall not proceed until recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or material.

I. Any deviation of submitted material or equipment from the Contract Drawings or Specifications shall be clearly marked in red ink on Submittals, and itemized in a transmittal letter, in order to receive consideration for approval.

J. Approval of material or equipment submittals containing deviations not specifically identified by Contractor shall not relieve the Contractor from compliance with specified requirements.

K. Thoroughly review and stamp all submittals to indicate compliance with Contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

L. Submittals will be reviewed for general compliance with design concept in accordance with Contract Documents, but dimensions, quantities, or other details will not be verified.

M. Increase, by the quantity listed below, the number of electrical related Shop Drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.

    1. Shop Drawings - Initial Submittal: 1 additional blue- or black-line print.

2. Shop Drawings - Final Submittal: 1 additional blue- or black-line print.
3. Product Data: 1 additional copy of each item.

N. Additional copies may be required by individual sections of these Specifications.

O. Shop Drawings (include but not limited to):

1. Prepare and submit SHOP DRAWINGS AND/OR DIAGRAMS for all specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on the contract drawings.
2. Shop drawings shall include plans, elevations, sections, mounting details of component parts, point to point interconnection diagrams, elementary diagrams, single line diagrams, and any other drawings necessary to show the fabrication and connection of the complete item or system.
3. Shop drawings shall be provided for, but not limited to the following items:

Analysis and Coordination Study
Automatic Transfer Switches
Ballasts
Basic Electrical Materials
Cable - 600 volt
Cable – Medium Voltage
Cable Tray
Circuit Breakers
Conduit and Surface Raceway
Contractor and Subcontractor Qualifications
Controllers & Control Devices
Disconnects
Electrical Connection Coordination Schedule
Engine/Generator
Equipment Connections
Equipment Pads
Excavation and Backfill
Fire Alarm Systems
Firestopping
Fuses
Ground Conductors, Rods
Identification System
Innerduct
Lamps
Lighting Control Equipment
Lighting Fixtures
Low Voltage Fuses
Material and Equipment List
Motor Starters
Occupancy Sensors
Outlet Boxes
PA System
Panelboards
Receptacles
Record and Information Booklet
Safety Switches
Schedule of Values
Sleeves, Hangers, Supports
Sound Systems

Special Systems
Submittal Schedule
Surge Protection Devices
Switchboards
Tests and Reports
Transformers
Underground Cable
Wiring Devices
Wiring Diagrams

P. The Contractor, additionally, shall submit for approval any other shop drawings as required by the Architect. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Engineer.

Q. The Contractor shall prepare and submit a Detail Schedule of Values indicating the Contract costs for the major work items. The Contractor shall provide additional detail and information as requested by the Engineer.

R. The Contractor shall prepare and submit a complete Submittal Schedule. The Schedule shall include a listing of all Submittals, Shop Drawings, and Coordination Drawings.

S. The Contractor shall review and coordinate with all other not order major electrical gear that serves HVAC and plumbing motors until all HVAC and plumbing equipment with motors have been reviewed. Additionally the Contractor shall review all mechanical and plumbing submittals for coordination items (disconnect switch, capacitors, etc.) prior to the Mechanical Contractor submitting products for review.

2.4 INSTALLATION AND COORDINATION DRAWINGS:

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of the work. Drawings shall include, but not be limited to the following:
   1. Telecommunication Rooms indicating data rack assemblies, panels, etc.
   2. Electrical Rooms indicating switchboard assemblies, transformers, equipment pads, panels, etc.
   3. Mechanical Equipment Rooms, including panels, transformers, starters, equipment, etc.
   4. Cable tray, light fixtures.

B. Draw plans to a scale not less than 1/4 inch equals one foot. Include plans of the proposed work, showing all equipment, major elements, conduit, and wiring in the areas involved. Fully dimension all work, horizontally and vertically. Show coordination with other work including piping, ductwork and other mechanical work, walls, doors, ceilings, columns, beams, joists, and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams. Where field connections are shown to factory-wired terminals, furnish manufacturer's literature showing internal wiring.

D. Prepare, submit, and use scaled layout drawings indicating dimensions, clearances, and actual equipment dimensions. Layout drawing shall include, but not be limited to the following:
   1. Pad-mounted equipment and equipment connections.
   2. Underground conduits, ductbanks, manholes, handholes, and building penetrations.

E. The Electrical Contractor shall develop and prepare an AutoCAD or Revit coordination model for the entire building to be used in conjunction with the mechanical, plumbing, structural and architectural model for coordination purposes. Model shall include major above ground feeders (2” and larger) cable trays, light fixtures, etc.

F. The Construction Manager shall schedule bi-weekly Coordination Drawing Reviews with the Owner, Mechanical Engineer, and all associated subcontractors, including but not limited to the following:

1. Mechanical Contractor
2. Finishes Contractor
3. Sheet Metal Contractor
4. Sprinkler Contractor
5. Electrical Contractor
6. Plumbing Contractor
7. Owner/Architect/Engineer
8. Commissioning Agent
9. Note: A Foreman or Project Manager responsible for Decision-Making of each company shall attend all Coordination Meetings.

I. The purpose of these meetings is to coordinate proposed installations of systems and equipment, including clearances, routing, penetrations, as well as to review potential conflicts. The Mechanical Contractor shall base preliminary equipment sizes and connections on proposed products and the final coordination drawing for review shall reflect approved/reviewed products. Coordination Meetings shall be held at the Contractor's Field Office.

2.5 RECORD DRAWINGS:

A. As the work progresses, record on a set of white prints the installed locations, sizes of electric feeders, equipment, etc. Upon completion of the work, submit one (1) complete set of white prints with "As-Built" information neatly recorded thereon in red ink. Use other colors to distinguish between variations in separate categories of the work. Note related change-order numbers where applicable. Provide electronic copies to the owner and architect at the completion of the project.

B. Write step-by-step detailed instructions for turn-on, turn-off, seasonal changeover, and periodic checks of all systems and equipment. Include all precautions and warnings.

C. Prepare a list of the manufacturers of all major equipment, their local service representative and procedures for obtaining service.

D. Post one (1) copy of all instructions, lists, charts, and diagrams at the equipment or where indicated, mounted under glass or approved plastic cover.

E. Furnish to the Owner two (2) copies of the Manufacturer's installation and operations instructions, and an electronic copy. Include replacement parts lists where applicable. Also include copies of all posted instructions, lists and charts. Assemble the material in one or more heavy duty 8- 1/2" x 11" loose leaf binders with tab separators. Submit for approval before final delivery. Binder shall be labeled on spine and on cover with Project Name.

F. Deliver all instruction materials to the Owner prior to the formal instruction period.

G. Deliver two (2) complete sets of all approved submittals to the Owner for filing, including electronic copies.

H. Prepare record documents in accordance with the requirements in the specifications. In addition to the requirements specified, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved Substitutions, Contract Modifications, and actual equipment and materials installed.

I. The Contractor shall keep at the site at all times during construction, one set of up-to-date Contract prints for the express purpose of showing any and all changes made during construction. The Contractor shall make the prints showing each change and shall incorporate all changes in "Record/As-Built Drawings" to be submitted to the Engineer upon completion of the project.

J. The Contractor shall show proof of up-to-date record drawings to the Owner prior to submitting monthly invoice.

K. The Contractor shall conform to all drawings, including all revisions, addendums, alternates, change orders, deletions, existing conditions, and as-built conditions without extra cost to the Owner.

2.6 DEMONSTRATION AND OPERATING INSTRUCTIONS

A. Furnish the necessary technicians, skilled workers, and helpers to operate the electrical systems and equipment of the entire project. The Contractor shall provide a minimum of three 2-hour sessions of system demonstration and operation for each system including, but not limited to: lighting controls, switchboards, generator, transfer switches.

B. Where specified in technical sections, provide longer periods required for specialized equipment.

C. Contractor shall provide start-up of all systems in an orderly, organized, and coordinated manner to ensure that all systems are functioning as designed. The Contractor shall provide a detailed start-up, testing, and demonstration plan for all systems in a coordinated manner that is documented in writing at least 45 days prior to system start-up. Start-up, testing and demonstration plans shall include detailed point-by-point checklists that clearly show that systems are, in fact, functioning as designed. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of systems and equipment.

D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by Instructors and Owner personnel.

E. Videotape each instruction session, including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVD video disks with each Operating and Maintenance Manual.

F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Engineer. All operation training and demonstrations shall be complete prior to Owner acceptance of any given system.

PART 3 - EXECUTION

3.1 EXAMINATION OF SITE, SURVEYS, AND MEASUREMENTS:

A. Examine the site, determine all conditions and circumstances under which the work must be performed, and make all necessary allowances for same. No additional cost to the Owner shall be permitted for Contractor's failure to do so.

B. Examine the site and observe the conditions under which the work will be done or other circumstances which will affect the contemplated work. No allowance will be made subsequently in this connection for any error or negligence on the Contractor's part.

C. The Contractor shall 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.

D. Any discovery of discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the Drawings and Specifications shall be brought to the attention of the Owner's Representative. Work shall not proceed until receiving instructions from the Owner's Representative.

E. The Contractor shall follow Drawings in laying out the work and check Drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Owner's Representative shall be notified before proceeding with the installation.

F. To prevent conflict with the work of other trades and for proper execution of the work, the Contractor, as directed by the Architect/Engineer, shall make the necessary modifications in the layout as needed, at no extra charge to the Owner.

G. The Contractor shall be solely responsible for the proper arrangement of his conduit and equipment.

H. The Engineer shall make all final decisions as to any conditions that require the changing of any work.

I. The Contractor shall have competent supervision on the site at all times to lay out, check, coordinate, and supervise the installation of all electrical work and be responsible for the accuracy thereof. He shall plan the installation of all electrical work, giving consideration to the work of other trades, to prevent interference.

J. The Contractor shall determine the location, size, etc., of all chases, sleeve openings, etc., required for the proper installation of the electrical work and see that such are provided. All chases, sleeves, openings, etc., shall be set prior to erection of new work to prevent delay in the progress of other work or trades.

K. Conditions and/or situations that prevent the proper installation of any equipment or item where shown on the Drawings shall be called to the attention of the Engineer for instructions.

L. The Contractor shall have equipment shipped or fabricated in sections of suitable size for entering the building and being removed from the finished building in the future, if necessary.

M. The Contractor shall fully investigate all peculiarities and space limitations for all materials and equipment.

N. Outlet, pull, and junction boxes and other appliances that require operation, examination, adjustment, servicing or maintenance shall be readily accessible.

O. The Contractor shall take all field measurements necessary for this work and shall assume responsibility for their accuracy.

P. The Contractor shall coordinate the electrical work with all other sub-contractors. All work shall be so arranged that there will be no delay in the proper installation and completion of any part or parts of electrical equipment. All electrical work shall be installed in proper sequence with other trades without any unnecessary delay.

Q. The Drawings are to some extent diagrammatic and indicate the general arrangement of the equipment, the runs of conduit, and the manner of connection.

R. The Contractor shall confer with all sub-contractors engaged in the construction of the project, regarding the work that may, in any way, affect his installation. Whenever interference occurs, before installing any of the work in question, the Contractor shall consult with all sub-contractors and shall come to an agreement with them as to the exact location and level of his conduit parts of his equipment.

S. The Contractor shall be responsible for determining exact property lines and area of work. The Contractor shall not install any equipment or conduits outside of the property lines and/or area of work without written direction from the Owner. Any work indicated diagrammatically on the Contract Documents to be installed beyond the property lines and/or area of work shall be verified with the Owner prior to installation.

3.2 GENERAL RESPONSIBILITIES:

A. The Contractor shall be responsible for systems and related damages possible, and shall hold harmless the Owner, the Architect and his consultants from malfunction of systems and equipment installed under this Contract as defined by the applicable state laws pertaining to real property for the period of time as defined by such laws.

B. It is the intent of these Specifications to fully cover without exception all required labor and materials so that the finished work will be delivered to the Owner in a complete and satisfactory working installation. Excavation, wiring, distribution, etc., shall be performed in compliance with the Contract Documents.

C. Work not specifically outlined, but reasonably incidental to the completion of the work, shall be included without additional compensation from the Owner.

D. Conflicting points in the Specifications or on the Drawings shall be called to the attention of the Architect prior to the execution of the Contract.

3.3 STORAGE AND PROTECTION OF EQUIPMENT

A. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, snow, rain, sleet or dust. Large diameter cables may be stored on reels with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened and made impervious to the elements.

B. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.

C. Switchboard, motor controllers, panelboards, breakers, emergency lighting, and supervisory equipment, if delivered to the construction site before the building is under cover, shall be warehoused and protected as follows: All gear and equipment shall be covered and protected from the elements and other damage and shall be stored in a clean, dry, heated atmosphere, under cover.

D. All gear and equipment delivered to the construction site after the building is under cover shall be protected as described above and in addition shall be provided with auxiliary heat to prevent condensation damage. The gear shall also be protected against damage caused by installation of any building systems and equipment; or damage caused by carelessness of workmen who are installing equipment connected to or adjacent to the above electrical equipment.

E. Equipment damaged as a result of the above conditions shall be properly repaired at the Contractor's expense or shall be replaced at the Contractor's expense, if, in the opinion of the Engineer the equipment has been damaged to such an extent it cannot operate properly after repairs are made.

F. All electrical enclosures exposed to construction damages such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs and pipe covering compound splashes, shall be completely covered and protected against damage.

G. In the event leakage into the building of any foreign material or fluid occurs or may occur, the Contractor shall take all steps as described above to protect any and all equipment.

H. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape and insulation removed in order to make the connection.

3.4 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, materials, and installation with landscape/irrigation contractor(s).
2. Verify all dimensions by field measurements.
3. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
4. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components where installed exposed in finished spaces.
5. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. All equipment and disconnects shall maintain proper working space to conform to NEC.
6. Install systems, materials, and equipment giving right-of-way priority to systems that require installation at a specified slope.
7. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installation.
8. Space, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work.

3.5 SUPERVISION AND COORDINATION:

A. Provide complete supervision, direction, scheduling and coordination of all work under the contract, including that of subcontractors, using full attention and the best skill. Be responsible for all work and make all subcontractors, suppliers and manufacturers fully aware of all requirements of the contract.

B. Coordinate the rough-in of all work performed under Mechanical & Electrical Divisions.

C. The Contractor shall coordinate all electrical rough-ins with approved shop drawings and coordination drawings. Any rough-in installed without complete coordination shall be at the Contractor's risk and expense.

D. Coordinate the installation of all necessary rough-in of work, sleeves, anchors and supports for conduit, wiring, and other work performed under Divisions Mechanical and Electrical Divisions.

E. Coordinate the spacing and arrangement of lighting fixtures, diffusers, grilles and access panels in ceilings to establish a symmetrical pattern.

F. Where a discrepancy exists within the Specifications or drawings or between the Specifications and Drawings, the more stringent (or costly) requirement shall apply until a clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of the Contractor to obtain a full and complete set of Contract Documents (either before or after bidding) will not relieve the Contractor of the responsibility of complying with the intent of the Contract Documents.

H. To insure proper electrical coordination between the electrical components supplied under the Electrical Divisions and the equipment supplied under the Mechanical Divisions, a schedule shall be submitted, prior to start of work and prior to fabrication of panels and/or gear which power is fed from, for review by the Engineer with the following column headings:

1. Equip. or Item	2. HP or KVA	3. Voltage and Phase	4. Power Factor	5. Capacitor	6. Motor Starter	7. Discon.	8.Controls	9.Remarks

Description of Column Headings:

1. List all the approved equipment furnished under Mechanical Division that requires electrical connections and designate the equipment as it appears in the Mechanical Divisions. Indicate the quantity, if more than one, in parentheses of identical equipment being supplied.
2. Indicate the supplied horsepower of the equipment listed under Column No. 1. If equipment listed has more than one motor, indicate each motor and its respective horsepower. Indicate the kVA rating for all other equipment requiring an electrical connection, unless the electrical connection is for a control circuit only.
3. Indicate the voltage and phase requirements for equipment listed under Column No. 1. If more than one electrical circuit or voltage is required for the listed equipment, it shall be so indicated. Indicate wiring required for connection, including all phase, neutral, and ground conductors.
4. Indicate the power factor rating for all motors listed under Column No. 2

5. Where a capacitor is to be provided, indicate specification it is supplied under and indicate the KVAR size for any capacitor provided under Division 26.
6. Where a motor starter is required, indicate the specification division it is supplied under and the type of motor starter; across-the-line, reversible, variable speed, two speed-single winding, etc. Indicate In Column No. 9 if the motor starter provided under Division 26 is not compatible with the motor specified.
7. Where a disconnect switch is required by the National Electric Code or by the contract documents for the equipment listed under Column No. 1, indicate under which Division the disconnect switch is supplied.
8. Indicate the Division under which the controls for the equipment listed under Column No. 1 are provided.
9. Indicate any discrepancies between what is indicated in the contract documents and what is actually being provided.

I. The Contractor shall fully coordinate the electrical connections to all equipment prior to installations, with the approved Shop Drawings and the trades involved. Coordination shall include voltage, phases, quantity and size of wiring, device sizes, terminations, rough-in work, and other coordination for a complete installation.

J. Coordinate Division 26 work with all trades.

K. Install work with proper clearances and access. Carefully examine all contract drawings and fit the work in each location without substantial alteration. Where departures are proposed or required, submit detailed drawings for acceptance. The right is reserved to make reasonable changes in location of equipment, conduit and wiring up to the time of rough-in or fabrication.

L. Coordinate light switch locations with door swings prior to rough-in. No switches permitted behind doors.

M. Coordinate electrical work with architectural items and equipment. Typical equipment refers to, but is not limited to, the following:
    1. Countertops, Casework and Cabinets.
    2. Fume and Exhaust Hoods.
    3. Kitchen equipment.
    4. Do not install outlets, switches, etc., behind casework, cabinets, etc.
    5. Data, phone, and other low voltage system outlets shall be mounted above the counter tops to match power outlets in the same areas.
    6. Coordinate counter top outlets with drilling of casework/counters.
    7. Coordinate surface raceways and outlets above and below counters with approved casework shop drawings to avoid conflicts with sinks and other appurtenances.
    8. Verify lab/kitchen equipment nameplates and connection requirements prior to rough-in.
    9. Shop equipment connections, including busways.

N. This Contractor shall make all system connections required to equipment furnished and installed under other divisions. Connections shall be complete in all respects to render this equipment functional to its fullest intent. The Contractor shall make all system connections required to equipment furnished under other Divisions. Circuits shall be extended to all equipment which is incidental to, but not necessarily shown, for equipment specified under other divisions such as magnetic flow meters, ATC panels, liquid level controls, leak detection systems, etc. Connections shall be complete in all respects to render this equipment functional to its fullest extent. Coordinate quantity, locations and power requirement for all items with the mechanical, plumbing and general trades contractors.

O. It shall be the responsibility of the Contractor to obtain complete instructions for connections.

3.6 GUARANTEE:

A. Guarantee obligations shall be as hereinbefore specified in the GENERAL AND SPECIAL CONDITIONS of these specifications, except as follows:
    1. Guarantee the complete electrical system free from all mechanical and electrical defects for the period of three (3) years beginning from the day of substantial completion of the work by the Architect. Refer to the Alternates specification section for additional years of guarantee. In all cases (base bid or alternates) specific equipment or materials warranties shall be guaranteed as stated hereinafter or as indicated on the drawings.
    2. Also, during the guarantee period, be responsible for the proper adjustments of all systems, equipment and apparatus installed by the Contractor and do all work necessary to ensure efficient and proper functioning of the systems and equipment.
    3. Upon receipt of notice from the Owner of failure of any part of the electrical installation during the guarantee period, new replacement parts shall be furnished and installed promptly at no cost.
    4. Warranty From the Manufacturer: Contractor shall obtain all warranty papers and records from the Original Equipment Manufacturer according to their warranty policy and deliver the same to the Owner. Contractor shall fulfill all the Original Manufacturer's requirements to validate the warranty as offered by the Original Equipment Manufacturer.

B. Provide 24-hour service for any and all warranty problems experience in the operation of the equipment provided.

C. Any equipment or system in need of warranty work whether during regular hours or on an emergency basis, shall be immediately serviced and repaired. The warranty work and guarantee shall include all parts and labor and shall be furnished at no cost to the Owner.

D. The Contractor shall guarantee to make good any and all defects in his work, exclusive of lamps, which may develop due to defective workmanship or materials, within three years from the date of final acceptance of the work by the Owner.

E. In addition to the warranty and correction of work obligations contained in the General and supplementary Conditions, correct the work of the system as embraced by the Specification, free from Mechanical and Electrical defects for the warranty period beginning from the day of acceptance of the building by the Architect for the beneficial use of the Owner.

F. During the warranty period, take responsibility for the proper adjustments of systems, equipment and apparatus installed and perform work necessary to ensure the efficient and proper functioning of the systems and equipment.

G. Certain items of equipment hereinafter specified shall be guaranteed for a longer time than the general warranty period. These guarantees shall be strictly adhered to and the Contractor shall be responsible for service or replacement required in connection with guarantee of these items. These guarantees shall commence on the same date as the final acceptance by the Architect.

H. Submission of a bid proposal for this Project warrants that the Contractor has reviewed the Contract Documents and has found them free from ambiguities and sufficient for the construction and proper operation of systems installed for this project. If discrepancies are found, have them clarified by Addendum.

I. It is possible that certain areas of the building or certain systems will be accepted at a time different than as specified. The date of acceptance by the Architect for beneficial use of the Owner for these building areas or systems will be adjusted accordingly.

3.7 SCHEDULING OF WORK:

A. The Contractor shall not be permitted to do any work in any area of any occupied building during normal hours, except in areas specifically assigned.

B. Coordination of work by the Contractor is essential such that power outages are kept to a minimum in quantity and duration. All required outages shall be approved by the Owner for optimum time scheduling. Written notice of not less than 15 calendar days shall precede all power outages. Utility disruptions during normal school hours are prohibited.

3.8 TEMPORARY FACILITIES:

A. General: Refer to the Division 1 Sections for general requirements on temporary facilities.

B. Description: Furnish and install the necessary metering and distribution equipment or an adequate, 3-phase, 4 wire temporary service and all temporary wiring, including step-down or step-up dry-type transformers. Exact requirements for temporary service will be determined by the Contractor.

C. The Contractor's attention is directed to the Occupational Safety and Health Act, Americans with Disabilities Act and NEC requirements for electrical work on construction sites.

D. Materials: Lights at each floor in each stair. At least one light outlet per 1200 square feet on each floor, exclusive of stairs.
   1. One 20-ampere circuit for each 7500 square feet of gross floor area per floor to which various trades may attach their cords.
   2. One temporary 220v power online in corridor (each elevator lobby) including connections to saws, fireproofing equipment and wood sanding equipment, if required.
   3. Power for testing and operating of elevators.
   4. Temporary lighting for stripping forms for all floors below grade.
   5. Power for crane operation.

E. Installation: Temporary lighting shall provide minimum foot candle levels for construction as follows:

AREA	FOOT CANDLE LEVEL
General construction area lighting, corridors, hallways and exit ways.	10
Electrical equipment rooms, active storerooms, shops, locker and dressing areas	10

F. The Contractor shall pay for all material and labor to provide and maintain temporary service.

G. The Contractor shall obtain and shall pay for temporary electrical service for construction power.

H. Provide all underground and/or overhead equipment, transformers, overcurrent devices, wires, connections, etc., for obtaining power from utility company lines.

I. Remove all temporary power installations and connections after permanent power is established and/or prior to completion of the project.

J. Contractor responsible for any and all temporary utility power connection fees.

3.9 DEMONSTRATION:

A. As a part of this contract, the Contractor shall provide for the services of equipment manufacturers or their established representatives to demonstrate to selected maintenance personnel the correct operation, safety and maintenance of all electrical equipment under this contract.

3.10 PAINTING AND FINISHES:

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc., shall be galvanized or stainless steel.

B. Clean surfaces prior to application of coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pre-treatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 26 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, conduit, and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed conduit, etc., shall be painted, except in electrical rooms, mechanical rooms, storage rooms, and crawl spaces. Colors shall be selected by the Architect and conform to ANSI Standards.

H. Submit color of factory-finished equipment for approval prior to ordering.

3.11 PROTECTION OF WORK:

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in conduit and equipment to prevent the entrance of water, dirt, debris, or other foreign matter.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

3.12 OPERATION OF EQUIPMENT:

A. Clean all systems and equipment prior to initial operation for testing, retesting, or other purposes. Set, adjust, and test all equipment in accordance with manufacturer's instructions. Do not oper-

ate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment.

C. Do not use electrical systems for temporary services during construction unless authorized in writing by the Owner. Where such authorization is granted, temporary use of equipment shall in no way limit or otherwise affect warranties or guaranty period of the work.

D. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.13 TESTING AND ADJUSTMENT

A. Perform all tests which are specified or required to demonstrate that the work is installed and operating properly. Where formal tests are required, give proper notices and perform all necessary preliminary tests to assure that the work is complete and ready for final test.

B. Adjust all systems, equipment and controls to operate in a safe, efficient and stable manner.

C. On all circuits, 600 volts or less, provide circuits that are free from ground faults, short circuits and open circuits.

D. Other tests of a specific nature for special equipment shall be as specified under the respective equipment.

3.14 IDENTIFICATIONS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS:

A. Contractor shall submit for approval schematic diagrams of each electrical system installed in the building. Diagrams shall indicate device location, service, type, make, model number and the identification number of each device in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under glass and hung in each Main Equipment Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All equipment shall be plainly tagged.

C. All items of equipment, including motor starters, panels, etc., shall be furnished with white letters and numbers on black plastic identification plates or aluminum letters and numbers on black engraved aluminum identification plates. Lettering shall be a minimum of 1/4" high. Identification plates shall be securely affixed to each piece of equipment, starters, panels, etc., by screws or adhesive (Tuff-Bond #TB2 or as approved equal). Pressure sensitive tape backing is prohibited.

D. Provide three (3) copies and electronic copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the "Record and Information Booklet" as hereinafter specified.

E. Provide at least 24 hours of straight time instruction to the operating personnel. This instruction period shall consist of not less than three (3) consecutive 8-hour days. Time of instruction shall be designated by the Owner. Provide two DVD/Digital copies of all instructional periods/demonstrations.

3.15 RECORD DRAWINGS AND SPECIFICATIONS:

A. Upon completion of the Electrical installations, the Contractor shall deliver to the Engineer one complete set of prints of the Electrical Contract Drawings which shall be legibly marked in red pencil to show all Addenda, approved Shop Drawings, Change Orders, changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings. Provide electronic copies of each.

B. The Contractor shall provide a record specification including all Addenda and other modifications. Record substantial variations in actual work performed. Identify all substitutions.

3.16 RECORD AND INFORMATION BOOKLET:

A. The Contractor shall have prepared three (3) copies of the Record and Information Booklet as well as an electronic copy and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three-ring loose-leaf binder similar to "National" No. 3881 with the following title lettered on the front and on the spine of the binder: "Record and Information Booklet (insert name of the project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pull-out. An Index will include the section tabs for each subject included. If more than one binder is required, print covers and spines with Volume numbers. Include in the front of every binder an index to all binders.
    1. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
    2. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
    3. Part 1: Directory, listing names, addresses, and telephone numbers of Electrical Engineers; Contractor; Electrical Subcontractors; and major Electrical equipment suppliers. Provide sales and service representative names and phone numbers of all equipment.
    4. Part 2: Operation and Maintenance Instructions, arranged by Specification Section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:
        a. Significant design criteria.
        b. List of equipment. Complete record of material list. Catalog brochures and product data for all components. Include all submittal comments, and corrected catalog data and shop drawings on each piece of equipment and each system.
        c. Parts list for each component, including recommended spare parts list. Include motor starter overload schedules.
        d. Operating instructions, including sequence of operation.
            i. Description of function, normal operating characteristics and limitations, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts. Provide a description of each system installed.
            ii. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; control, stopping.
        e. Maintenance instructions for equipment and systems. Detailed checkout procedures to insure operation of systems and gear, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

f. Servicing, diagnostic and troubleshooting instructions and procedures for systems and major equipment.
g. Recommended preventative maintenance program, including a list of items requiring inspection and servicing. Provide Chart Form indicating time and type of routine and preventative maintenance of electrical equipment, etc. The chart shall also indicate tag number, model number of equipment, location and service.
    i. For replacement items, indicate type, size and quantity of the replaceable items.
    ii. Provide lubrication schedule, including type, grade, temperature range and frequency.
    iii. Provide a list of each type of lighting fixture lamp used, lamp fixture used, and source.
    iv. Include estimated mean time between failures for major parts.
h. Wiring Diagrams, Block Diagrams, and Assembly Drawings.
    i. Panelboard Circuit Directory for each panelboard, including Panel Name, Panel Location, Panel Ratings, spare circuit breakers, spaces for additional circuit breakers.
i. List of equipment keys turned over to the Owner.

5. Part 3: Project Documents and Certificates, including the following:
    a. Shop Drawings and Product Data. Record Documents of the systems.
    b. Photocopies of certificates.
    c. Photocopies of Manufacturers' and Contractors' warranties, guarantees.
    d. Test Reports: Copies of the approved results of all tests required under all sections of specifications.
    e. Inspection Certificates.
    f. Manufacturer's Conformance Certificates.
6. Provide one copy (DVD video disk) of video instruction session with each booklet set. Label video disk with all pertinent information.
7. Submit one copy of completed volumes in final form 15 days prior to final Inspection. This copy will be returned with Engineer comments. Revise content of documents as required prior to final submittal.
8. Submit final volumes revised and electronic copies, within ten days after final inspection.

C. Upon completion of the project, the Contractor shall furnish the Owner a complete list of suppliers of equipment for parts and maintenance purposes. The list shall include the name, address, and telephone number of the parts and maintenance firm on a single 8-1/2" x 11" sheet of paper.

D. This item shall include the furnishing of a complete list of equipment installed on the project, including the Manufacturer's name, the make and model number of the equipment, and address and telephone number of the nearest supplier who stocks maintenance and/or replacement parts. The list should be submitted along with as-built drawings and be typed in an organized manner.

- END OF SECTION 26 05 01 -

SECTION 26 05 19
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. Section Includes:

1. Aluminum building wire rated 600 V or less.
2. Copper building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Metal-clad cable, Type MC Luminary Cable, rated 600 V or less.
5. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260533 “Raceways and Boxes for Electrical Systems”

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

1.4 INFORMATIONAL SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location and termination locations.

1.5 QUALITY ASSURANCE

A. Electrical devices, accessories and components; are certified by a testing agency approved by the local authority having jurisdiction, and are listed and labeled per NFPA 70 Article 100.

B. Installation shall comply with applicable nation, state and local electrical codes and NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Alpha Wire Company.
2. American Bare Conductor.
3. Belden Inc.
4. Cerro Wire LLC.
5. Southwire Company.
6. WESCO.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Aluminum, complying with ASTM B 800 and ASTM B 801.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.

2.3 COPPER BUILDING WIRE

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. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

D. Conductor Insulation:

1. Type NM: Comply with UL 83 and UL 719.

2. Type USE-2and Type SE: Comply with UL 854.
3. Type THHN and Type THWN-2: Comply with UL 83.
4. Type XHHW-2: Comply with UL 44.

2.4 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

1. Single circuit.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Insulated.

F. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.

G. Armor: Steel; interlocked.

H. Jacket: PVC applied over armor.

2.5 METAL-CLAD CABLE, TYPE MC, MC LUMINARY CABLE

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

1. Single circuit.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Insulated.

F. Conductor Insulation:

1. Type THHN: No. 10 and No. 12 AWG; power conductors.
2. Type TFN: No. 16 AWG twisted pair; control conductors

G. Armor: Steel; interlocked.

H. Jacket: PVC applied over armor.

2.6 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:

1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Gardner Bender.
4. Hubbell Power Systems, Inc.
5. Ideal Industries, Inc.
6. O-Z/Gedney; a brand of Emerson Industrial Automation.
7. TE Connectivity Ltd.
8. Thomas & Betts Corporation; A Member of the ABB Group.

C. Connectors:

1. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with compression fittings, designed to connect conductors specified in this Section.
2. Split Bolt & Set Screw Connectors: Not Acceptable.
3. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.
4. Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment pads or terminals. Not approved for splicing.
5. All wire connectors used in underground or exterior pull boxes shall be gel-filled twist connectors or a connector designed for damp and wet locations.
6. Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic high conductivity copper tubing, internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps. Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.
7. Heat shrinkable tubing shall meet the requirements of ANSI C119.1-1986 for buried connections to 90°C and shall be material flame-retarded per IEEE 383 “Vertical Tray Flame Test”. Motor connection kits shall consist of heat-shrinkable, polymeric insulating material over the connection area and a high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Motor connection kits shall accommodate

a range of cable sizes for both in-line and stub-type configurations. Connection kits shall be independent of cable manufacturer's tolerances

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: Two hole with standard barrels.
3. Termination: Compression.

E. Wire Connectors:

1. Wire nuts installed in wet locations, exterior, etc., shall be self-contain, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air.
2. Connectors shall be UL listed appropriately sized according to manufacturer's recommendations for the suitable wire sizes and voltage ratings.
3. Connectors' body shall have a color-coded outer shell.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, unless otherwise indicated on the Contract Documents.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type MC Cable.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Accessible Ceilings, Drywall Walls, and Drywall Partitions: Type MC Cable.

F. Branch Circuits Concealed in Inaccessible Ceilings, Masonry Walls: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. Type MC Luminary Cable may be used in short lengths (12-foot maximum) for final connections to lighting fixtures and may be used between light fixtures for 0-10V control.

J. Class I Control Circuits: Type THHN-THWN, in raceway.

K. Class II Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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. Lubricant shall be water based, no Yellow 77.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Branch circuits of 120V, wire size shall be as follows:

1. Homerun from panelboard to first outlet: size as indicated on E0.1 “20 Ampere Circuits” Chart.
2. From first outlet to other outlets: No. 12.

H. All circuits for exterior electric work shall be No. 10 (minimum) and contain and extra No. 10 copper ground conductors. All exterior wiring shall be installed in conduit as specified above, unless otherwise noted as larger on the Drawings.

I. Homeruns from panelboard to a junction box in accessible concealed space above or below the first device or outlet will be wire in EMT raceway and not MC Cable. MC Cable will not be used for homeruns.

J. All splices shall be done in junction box and/or outlet boxes; splices shall not be in conduit.

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-486B.

B. Make splices, terminations, and taps that are compatible with conductor material.

C. Splices shall be done in junction boxes and/or outlet boxes only.

1. Conductors No. 10 and smaller, use wire connectors.
2. Conductors No. 8 and larger, shall be of the type indented into the conductor by means of a hand or hydraulic pressure tool.

D. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 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.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. 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."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

- END OF SECTION 26 05 19 -

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

a. Test wells.
b. Ground rods.
c. Ground rings.
d. Grounding arrangements and connections for separately derived systems.

2. Instructions for periodic testing and inspection of grounding features at test wells ground rings grounding connections for separately derived systems based on NETA MTS 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.

1.5 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 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 UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 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. Burndy; Part of Hubbell Electrical Systems.
2. Dossert; AFL Telecommunications LLC.
3. ERICO International Corporation.
4. Fushi Copperweld Inc.
5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning & Grounding.
7. ILSCO.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Robbins Lightning, Inc.
10. SIEMENS Industry, Inc.; Energy Management Division.

2.3 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. 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 and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 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. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

J. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

L. Straps: Solid copper, copper lugs. Rated for 600 A.

M. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one two-piece clamp.

N. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

O. Water Pipe Clamps:

1. Mechanical type, two pieces with 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.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet (19 mm by 3 m).

B. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.

C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, 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; connect to horizontal bus.

D. 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 SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.5 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.

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. 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.

F. Signal and Communication Equipment: 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.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-24-inch (6-by-50-by-600-mm) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.6 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 Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. 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.

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.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. 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.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. 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 Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
3. Substations and Pad-Mounted Equipment: 5 ohms.
4. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

- END OF SECTION 26 05 26 -

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates: For hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

C. Welding certificates.

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. Manufacturers: Subject to compliance with requirements, provide slotted metal angle and U-channel systems by one of the following:

a. Thomas & Betts Corporation; Kindorf
b. Unistrut; Diversified Products
c. Power-Strut.

2. Manufacturers: Subject to compliance with requirements, provide conduit sealing bushings and accessories by one of the following:

a. Bridgeport Fittings
b. GS Metals, Corporation

c. O-Z / Gedney
d. Raco, Inc.

3. Material: Pre-galvanized steel.
4. Channel Width: 1-1/4 inches (31.75 mm).
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
9. Channel Dimensions: Selected for applicable load criteria.

B. 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.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored 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 made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel stainless steel, for use in hardened portland cement concrete, 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) Caddy Fasteners; Eric Products
2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) Wej-It Fastening Systems

2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.
7. Powder actuated fasteners and drive pin type fasteners are not acceptable.

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 Section 055000 "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 unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

D. 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 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) 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. 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 (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "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/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) 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 (20.7-MPa), 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. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

B. Touch Up: Clean welds and abraded areas of shop paint. Paint exposed areas after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA1.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

- END OF SECTION 26 05 29 -

SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.2 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

C. MR Credit 3: BPDO – Sourcing of Raw Materials

1. For recycled content conduit: Documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include material cost value.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Appleton
4. Cooper Course-Hinds
5. O-Z Gedney; a unit of General Signal.
6. Spring City
7. Thomas & Betts
8. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel.
b. Type: Compression type.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

I. Joint Compound for IMC, GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

1. Allied Tube & Conduit
2. Arnco
3. Beck Manufacturing
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Carlon

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

G. Fittings for LFNC: Comply with UL 514B.

2.3 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. 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.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal.

2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, round.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep).

M. Gangable boxes are allowed.

N. Hinged-Cover Enclosures: Comply with UL 50 and 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. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. 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.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

C. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. 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.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.

1. 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.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC." “Telephone”.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC direct buried unless otherwise noted.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4X, Stainless Steel.

B. Indoors: Apply raceway products as specified below unless otherwise indicated.

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC Raceway locations include the following:

   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Boiler rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: MC Cable.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Aluminum conduit is prohibited.

E. 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. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression type, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

F. Do not install aluminum boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

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. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.

D. Arrange stub-ups so curved portions of bends are not visible above finished slab.

E. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

F. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

G. Support conduit within 12 inches ((300 mm)) of enclosures to which attached.

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. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from RNC, Type EPC-40-PVC to GRC before rising above floor, including into wall cavity.

I. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

J. 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.

K. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

N. 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. Cap underground raceways designated as spare above grade alongside raceways in use.

O. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with two hole straps at intervals not exceeding 32 inches (813-mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

P. Install raceway sealing fittings at accessible locations according to NFPA 70 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.

Q. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

R. Expansion-Deflection Fittings: Provide an expansion/deflection fitting in each concealed or exposed electrical run crossing a building expansion joint. Fittings shall be complete with bronze end couplings, neoprene sleeve, tinned copper braid integral bonding jumper and stainless steel bands. Expansion/deflection fittings shall be suitable for the size and type of conduit run they connect. Bonding jumper shall comply with NEC and UL requirements.

1. Expansion/deflection fitting shall accommodate the following movements without collapsing or fracturing the conduit and damaging the wires it contains:

   a. Axial expansion or contraction up to 3/4-inch.
   b. Angular misalignment of the axes of the conduits up to 30 degrees in all directions.
   c. Parallel misalignment of the axes of the conduits up to 3/4-inch in all directions.

2. Expansion/Deflection fitting shall be OZ/Gedney Type DX or approved equal by Crouse Hinds (Type XD).

S. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, 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.

T. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.

U. 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. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.

V. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

W. Locate boxes so that cover or plate will not span different building finishes.

X. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

Y. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

Z. Set metal floor boxes level and flush with finished floor surface.

AA. 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 Section 312000 "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-up at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

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 with bottom below frost line below grade.

E. 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.

F. 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.

G. Field-cut openings for ducts and 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.

H. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 7 Section "Joint Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

- END OF SECTION 26 05 33 -

SECTION 26 05 43
UNDERGROUND DUCTBANKS

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. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
2. Handholes and boxes.
3. Manholes.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes**,** and other utility structures.
4. Warning tape.
5. Warning planks.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

D. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

E. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

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

G. Source quality-control test reports.

H. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

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

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Division 26 Section.
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

   a. Color.
   b. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.3 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have 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," "TELEPHONE," or as indicated for each service.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long**)** and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. 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. 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.

2.4 PRECAST MANHOLES

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. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast Group.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile Inc.

B. Comply with ASTM C 858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

E. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

1. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
2. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
3. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.
2. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.

G. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.

H. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.5 UTILITY STRUCTURE ACCESSORIES

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. Bilco Company (The).
2. Campbell Foundry Company.
3. Christy Concrete Products.
4. East Jordan Iron Works, Inc.
5. Elmhurst-Chicago Stone Co.
6. McKinley Iron Works, Inc.
7. Neenah Foundry Company.
8. NewBasis.
9. Oldcastle Precast Group.
10. Osburn Associates, Inc.
11. Pennsylvania Insert Corporation.
12. Quazite:Hubbell Power Systems, Inc.

13. Rinker Group, Ltd.
14. Riverton Concrete Products.
15. Underground Devices, Inc.
16. Utility Concrete Products, LLC.
17. Utility Vault Co.
18. Wausau Tile Inc.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches (725 mm).

   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.

   a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
   a. Seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.

C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

D. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.

E. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

F. Ground Rod Sleeve: 3-inch (75-mm), PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

G. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

H. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

I. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

J. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). One required.

K. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater. Two required.

2.6 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes 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 the 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 PREPARATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Division 31 Section "Clearing." Remove and stockpile topsoil for reapplication according to Division 31 Section "Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

C. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

D. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

E. Underground Ducts Crossing Paved Paths, walks, driveways and roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

F. Ducts for electrical feeders over 600V: RNC, NEMA Type EPC-80-PVC, direct-buried, unless otherwise noted.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Units 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.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving - Civil" and "Earth Moving – Structural" but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections “Topsoiling, Seeding and Sodding” and “Trees, Shrubs and Ground Covers”.

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.5 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 25 feet (7.5 m), both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Basic Electrical Materials and Methods."

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

G. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using

fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Stub-Ups: Use 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. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

9. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.

3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving - Civil" and “Earth Moving – Structural” for pipes less than 6 inches (150 mm) in nominal diameter.
4. Install backfill as specified in Division 31 Section "Earth Moving - Civil" and “Earth Moving – Structural”. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving - Civil" and “Earth Moving – Structural”.
5. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.
6. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
7. Set elevation of bottom of duct bank below the frost line.
8. 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.
9. 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 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.

10. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above direct-buried ducts and duct banks, placing them 24 inches (600 mm) o.c. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07. After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms as required for installation and support of cables and conductors and as indicated.

H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 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 ducts and 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.

G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

- END OF SECTION 26 05 43 -

SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 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 078443 "Joint Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

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 (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

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

   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, 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.

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

   a. HOLDRITE.

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 (34.5-MPa), 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 (6.4-mm) 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 3 inches (76.2 mm) 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 pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing 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 26 05 44 -

SECTION 26 05 48.16
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. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. 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.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting 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 caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.

   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. 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).

1.4 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. Electrical components include:

   1. Generators.
   2. Automatic Transfer Switches.
   3. Panelboards.
   4. Switchboards.
   5. Transformers.

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

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated 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/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. 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) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading

1. Refer to Structural Drawing S0.1.

2.2 RESTRAINT CHANNEL BRACINGS

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. 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, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

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. Gripple Inc.
2. Kinetics Noise Control, Inc.
3. Vibration & Seismic Technologies, LLC.
4. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 603 galvanized-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.

2.4 SEISMIC-RESTRAINT ACCESSORIES

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. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. TOLCO; a brand of NIBCO INC.

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.

2.5 MECHANICAL ANCHOR BOLTS

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. 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.

2.6 ADHESIVE ANCHOR BOLTS

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. 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 seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for 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 caused by 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. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

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

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

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

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole

and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 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 connection is terminated 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.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

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.

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

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

- END OF SECTION 26 05 48.16 -

SECTION 26 05 53
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. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME 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. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:

   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral: White.

3. Colors for 480/277-V Circuits:

   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: Gray.
4. Color for Equipment Grounds: Green.
5. Colors for Isolated Grounds: Green with white stripe.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs 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)."

2.3 LABELS

A. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameter and that stay in place by gripping action.

1. Manufacturers:

   a. Brady Corporation.
   b. Hellermann Tyton.

c. Marking Services, Inc.
d. Panduit Corp.
e. Seton Identification Products.

B. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3 mil (0.08 mm) thick, multicolor, weather and UV resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers:

a. Brady Corporation.
b. Hellermann Tyton.
c. Marking Services, Inc.
d. Panduit Corp.
e. Seton Identification Products.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameter and that stay in place by gripping action.

1. Manufacturers:

a. Brady Corporation.
b. Hellermann Tyton.
c. Marking Services, Inc.
d. Panduit Corp.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers:

a. Carlton Industries, LP
b. Champion America
c. Hellermann Tyton
d. Ideal Industries, Inc.
e. Marking Services, Inc.
f. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

1. Manufacturers:

a. Brady Corporation.
b. Carlton Industries, LP
c. Emedeo
d. Marking Services, Inc.

C. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

1. Manufacturers:

a. Carlton Industries, LP
b. Seton Identification Products.

D. Detectable Underground-Line Warning Tape:

1. Manufacturers:

a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products, Inc.
d. Marking Services, Inc.
e. Reef Industries, Inc.
f. Seton Identification Products.

2. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.6 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers:

a. Carlton Industries, LP
b. Champion America
c. Emedco
d. Marking Services, Inc.

2. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Metal-Backed Butyrate Signs:

1. Manufacturers:

a. Carlton Industries, LP
b. Champion America
c. Emedco
d. Marking Services, Inc.

2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 10 by 14 inches (250 by 360 mm).

C. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers:

a. Carlton Industries, LP
b. Champion America
c. Emedco
d. Marking Services, Inc.

2. Engraved legend.
3. Thickness:

a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick).
b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
c. Engraved legend with white letters on a black background.
d. Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

1. Manufacturers:

a. Hellerman Tyton
b. Ideal Industries, Inc.
c. Marking Services, Inc.
d. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and 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.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and 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.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and 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.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain 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 and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

H. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer, emergency power.

L. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

M. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:

1. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. 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.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

R. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

S. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

T. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway 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.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

U. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

V. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

W. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

X. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 20 A and 120 V to Ground: Identify with snap-around labels applied in bands.

1. Locate identification label at 10 foot (3-m) maximum intervals.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. “Security System” – blue and yellow.
2. “Power” – orange.
3. "Emergency Power” – yellow.
4. “Control Wiring” – green and red.
5. “Mechanical & Electrical Supervisory System” – green and blue.
6. “Fire Alarm System” – red.
7. “Telecommunication System” – green and yellow.

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels to identify the phase.

1. Locate identification 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.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive wraparound labels with the conductor designation.

H. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

I. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

J. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

K. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.
2. 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. Arc Flash Warning Labeling: Self-adhesive labels.

N. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

O. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and emergency power.

P. Equipment Identification Labels:

1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to be labeled (all may not apply to this project):

a. Panelboards, electrical cabinets, and enclosures.
b. Access doors and panels for concealed electrical items.
c. Electrical switchgear and switchboards.
d. Transformers.
e. Electrical substations.
f. Emergency system boxes and enclosures.
g. Motor-control centers.
h. Disconnect switches.
i. Enclosed circuit breakers.
j. Motor starters
k. Push-button stations.
l. Power transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Battery inverter units.
p. Battery racks.
q. Power-generating units.
r. Voice and data cable terminal equipment.
s. Master clock and program equipment.
t. Time clocks
u. Intercommunication and call system master and staff stations.
v. Television/audio components, racks, and controls.
w. Fire-alarm control panel and annunciators.
x. Security and intrusion-detection control stations, control panels, terminal cabinets and racks.
y. Monitoring and control equipment.
z. Uninterruptible power supply equipment.
aa. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.
bb. Dimmers.
cc. Transformers.

- END OF SECTION 26 05 53 -

SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

B. Review of electrical equipment shop drawings shall be preliminary in nature, for general compliance to specifications. The electrical equipment (including switchboards, panelboards, transformers, etc.) **shall not be released, purchased or installed** by the Contractor, until after Overcurrent Protective Device Coordination Study is submitted and reviewed by the Engineer. Failure to do so, may/will result in the rejection and/or removal of the equipment submitted/purchased/installed by the Contractor at the Contractor's expense.

C. Arc-Flash labels shall be provided on all electrical distribution equipment with label as indicated by study.

1.2 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. 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. Overcurrent protective device coordination 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.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.
2) Protective device coordination study.
3) Time-current coordination curves.

b. Power system data.

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 unacceptable.

B. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

1. Coordinated Power Engineering, Inc.
2. CGI Cyme
3. EDSA Micro Corporation.
4. ESA, Inc.
5. Operation Technology, Inc.
6. Power Analytics Corporation.
7. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

D. 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.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
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. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

a. Phase and Ground Relays:

1) Device tag.
2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

F. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

a. Power utility's overcurrent protective device.

b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
d. Transformer full-load current, magnetizing inrush current.
e. Ground-fault protective devices.
f. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

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 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. 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.

F. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Low-voltage switchgear.
3. Motor-control centers.

4. Standby generators and automatic transfer switches.
5. Branch circuit panelboards.

H. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. Use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. 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 percent, and phase shift.
8. 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.
9. Maximum demands from service meters.
10. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
11. Motor horsepower and NEMA MG 1 code letter designation.
12. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
13. 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. Ratings, types, and settings of utility company's overcurrent protective devices.
    c. Special overcurrent protective device settings or types stipulated by utility company.
    d. Time-current-characteristic curves of devices indicated to be coordinated.
    e. 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.

f. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
g. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

3.4 ARC-SLASH HAZARD

A. Perform Arc-Flash Hazard Analysis and provide results indicating personnel protective equipment required for the potential hazard.

3.5 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.6 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.

- END OF SECTION 26 05 73 -

SECTION 26 05 74
OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 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.

1.2 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.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.4 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 017700 "Closeout Procedures," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.5 QUALITY ASSURANCE

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.

A. 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.

B. 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.

C. 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 SOFTWARE DEVELOPERS

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

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory 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. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

F. 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.

G. 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.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

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. 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 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 shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five 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 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.

B. Electrical Survey Data: Gather and tabulate the following input data to support study.

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. 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.
5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
6. Motor horsepower and NEMA MG 1 code letter designation.
7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 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 26 05 74 -

SECTION 26 08 00
ELECTRICAL SYSTEM COMMISSIONING

PART I – GENERAL

1.01 WORK INCLUDED
- A. Systems and equipment testing and start-up.
- B. Validation of proper and thorough installation of Division 26 systems and equipment.
- C. Functional performance testing of electrical systems.
- D. Documentation of tests, procedures, and installations.
- E. Coordination of Training Events.
- F. Generic Start-Up Procedures for electrical systems and equipment.

1.02 RELATED
- A. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- B. Commissioning Authority (CA) shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.
- C. This Section outlines the Cx procedures specific to the Division 26 Contractors. Requirements common to all Sections are specified in Sections 01 19 13 and 01 19 15 and the Commissioning Plan.

1.03 SCOPE
- A. The following are included in the Scope of Commissioning on this project:
  1. Automatic Transfer Switches
  2. Emergency Power Engine Generators and Distribution Systems
  3. Lighting and Lighting Controls
  4. Integrated Lighting Control Systems
  5. Electric Distribution Power Monitoring System

1.04 RELATED WORK AND DOCUMENTS
- A. Commissioning Plan: The Commissioning Plan shall be considered a part of the Contract Documents and outlines many of responsibilities, procedures and tasks throughout the Cx process. It encompasses the entire Cx process including design phase tasks prior to construction. It also describes the Functional Performance Tests that will be performed during the Acceptance Phase.
- B. Section 01 33 00 – Submittals: Stipulates additional copies of submittals to be submitted and refers to other sections for additional submittal requirements related to Cx.
- C. Section 01 77 00 – Project Close Out: Defines the milestones in completion incorporating the Cx process
- D. Section 01 19 13 – General Commissioning Requirements: details the Cx requirements common across all divisions
- E. Section 01 19 15 – Functional Testing Procedures: Outlines the generic functional testing procedures required.
- F. Individual Specification Sections: Individual sections stipulate installation, start-up, warranty, O&M documentation, and training requirements for the system or device specified in the Section.
- G. Section 23 08 00 – HVAC Systems Commissioning: Details the commissioning procedures specific to HVAC (Division 23) work.

O. Section 23 08 59 – Instrumentation and Control Systems Commissioning: Details the commissioning procedures specific to the Building Automation System.

1.05 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 19 13 and the Commissioning Plan.

1.06 REFERENCE STANDARDS

A. National Electric Code (NEC)
B. American Society for Testing and Materials (ASTM)
C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)
D. Illuminating Engineering Society (IES)
E. Institute of Electrical and Electronics Engineers (IEEE)
F. International Electrical Testing Association (NETA)
G. National Electrical Manufacturers Associates (NEMA)
H. National Fire Protection Association (NFPA)
I. Underwriters Laboratory, Inc. (UL)
J. LEED v4 for Building Design and Construction released in 2013.

1.07 DOCUMENTATION

A. In addition to the documentation required in Section 01 19 13, Contractor shall provide to the CA the following per the procedures specified herein, in the Commissioning Plan, and in other Sections of the specification:
   1. Short Circuit and Coordination Study: CA shall review and recommend approval.
   2. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports should be provided in pdf electronic format. These include but are not limited to:
   3. Field Testing Agency Reports: Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in pdf electronic format. These include but are not limited to:
      a) Electrical Testing Agency Reports per specifications
      b) Thermographic Survey Report
      c) Generator Load Testing
   4. Sample of distribution panel and receptacle labeling for approval.
   5. Fire Alarm System Approvals and Certifications.

1.08 SEQUENCING AND SCHEDULING

A. Refer Section 01 19 13 and the Commissioning Plan.

1.09 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 19 13 and the Commissioning Plan but shall be refined and documented in the Construction Phase Cx Kick-Off meeting. Contractor shall have input in the protocols and all Parties will commit to scheduling obligations. The CA will record and distribute.

1.10 CONTRACTOR RESPONSIBILITIES

A. Refer to Section 01 19 13: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 19 13. The following are additional responsibilities or notable responsibilities specific to Division 26.
B. Construction Phase
   1. Coordinate the work of the Electrical Testing Agency and the Cx requirements.
   2. Coordinate the checkout of the Fire Alarm System and the approval of the regulatory authorities with the Cx process.
   3. Provide skilled technicians qualified to perform the work required.

4. Provide factory-trained and authorized technicians where required by the Contract Documents.
5. Prepare and submit required draft Start-Up Procedures and submit along with the manufacturer's application, installation and start-up information.
6. Provide assistance to the CA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
7. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
8. Record Start-up Procedures on start-up procedure forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above. Each task or item shall be indicated with the Party actually performing the task or procedure.

C. Acceptance Phase
1. Assist CA in functional performance testing. Assistance will generally include the following:
a) Manipulate systems and equipment to facilitate testing (as dictated in Section 01 19 15 and the Commissioning Plan; in some cases, this will entail only an initial sample);
b) Provide any specialized instrumentation necessary for functional performance testing;

1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES
A. Refer to Section 01 19 13.

1.12 CONTRACTOR NOTIFICATION AND SCHEDULING
A. Refer to Section 01 19 13.

1.13 START-UP PROCEDURES AND DOCUMENTATION
A. Refer to Section 01 19 13.

1.14 EQUIPMENT NAMEPLATE DATA
A. Refer to Section 01 19 13.

1.15 INDEPENDENT ELECTRICAL TESTING AGENCY
A. The Independent Electrical Testing Agency shall be provided under the construction specifications and therefore included with the bid. Many of the aspects of the start-up and functional performance testing indicated herein will be accomplished under the respective section and witnessed by the CA at the indicated sample rate. CA will include applicable test results in the functional performance testing record.

1.16 FUNCTIONAL PERFORMANCE TESTING
A. For applicable systems and equipment, Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 01 19 13 and Section 01 19 15.

1.17 FPT ACCEPTANCE CRITERIA
A. Acceptance criteria for tests are indicated in Section 01 19 15 and in the specification Sections applicable to the systems being tested. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device, which in general conform to NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1991.

1.18 TRAINING

A. Contractors, subcontractor, vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 19 13 and the individual Specifications.

1.19 SYSTEMS MANUAL CONTENT

A. Refer to Section 01 19 13 the individual Specifications.

PART II - PRODUCTS

2.01 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply: All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. Testing Instrumentation: Contractor shall provide all instrumentation necessary for tests for which they are responsible. CA will provide standard instrumentation for measuring medium and low voltage electrical voltage, current, power factor, power, and THD. CA will provide receptacle testers for normal and GFI receptacle tests. Contractor shall provide all other instrumentation required to accomplish the specified testing.

PART III – EXECUTION

3.01 START-UP PROCEDURES – GENERAL

A. Part III of this Section outlines 'generic' or minimally acceptable Start-Up Procedures (delineated as Start-Up Checks and Start-Up Tests) and individual systems Training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimum or guideline for required Contractor development of Start-Up Procedures. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized Start-Up Procedures specific to the equipment and systems installed on this project.

3.02 TESTING PROCEDURES

A. Thermographic Scanning
   1. The infrared scan shall be made when the equipment is energized and is operating at its normal capacity, unless otherwise noted. It is intended that the scan be made after the equipment has been in full operation; however, the exact time of conducting the scan will be determined by the CA near the completion of the project.
   2. Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable to perform all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.
   3. All hot spots shall be marked, identified and an infrared thermographic scanning report prepared and furnished to the Owner.
   4. The report shall contain infrared photos of trouble spots with temperature readings.
   5. All sources of heating problems shall be promptly reported to the Owner for corrective action by the Division 26 contractor.

B. Grounding Systems
   1. Perform three-point fall-of-potential test per IEEE Standard 81 on the main grounding electrode or system. Resistance shall be no greater than 5 ohms.

2. Perform the two-point method test per IEEE Standard 81 to determine the ground resistance between the main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points. Resistance shall be no greater than 5 ohms.

3.03 PROCEDURES COMMON TO ALL SYSTEMS

A. The following start up verifications/procedures are common to all systems
   1. Checkout shall proceed from devices to the components to the systems.
   2. Verify labeling is affixed per spec and visible
   3. Verify prerequisite procedures are done.
   4. Inspect for damage and ensure none is present.
   5. Verify system is applied per the manufacturer's recommendations
   6. Verify system has been started up per the manufacturer's recommendations
   7. Verify that access is provided for inspection, operation and repair
   8. Verify that access is provided for replacement of the equipment
   9. Verify the record drawings, submittal data and O&M documentation accurately reflect the installed systems
   10. Verify all gages and test ports are provided as required by contract documents and manufacturer's recommendations
   11. Verify all recorded nameplate data is accurate
   12. Installation is done to ensure safe operation and maintenance.
   13. Verify specified replacement material/attic stock has been provided as required by the Construction Documents
   14. Verify all rotating parts are properly lubricated
   15. Verify all monitoring and ensure all alarms are active and set per Owner's requirements

3.04 AUTOMATIC TRANSFER SWITCHES (ATS)

A. General: Provide the services of a manufacturer-certified specialist to supervise the installation, make adjustments, and perform tests on the automatic transfer switches and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.
B. Start-Up Checks: During startup, perform the following checks and any additional checks specified in manufacturer's instructions.
   1. Visually inspect the systems.
   2. Ensure the terminations are tight and all ancillary equipment completely installed.
   3. Ensure all overloads are in place.
C. Start-Up Tests: During startup, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
   1. Electrical tests listed in NETA 7.22.3.2.
D. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

3.05 EMERGENCY POWER ENGINE GENERATORS AND DISTRIBUTION SYSTEMS

A. General: Provide the services of a manufacturer certified specialist to supervise the installation, make adjustments, and perform tests on the engine generators and emergency power switchgear and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.
B. Start-Up Checks: During startup, perform the following checks and any additional checks specified in manufacturer's instructions.
   1. Visually inspect the systems.
   2. Ensure the terminations are tight on power and control wiring.
   3. Verify all ancillary equipment completely installed.
   4. Ensure all overloads are in place.

5. Verify that generator is set in place.
6. Verify fuel connections.
7. Verify radiator connections.
8. Verify battery connection.
9. Verify exhaust connections.
10. Verify block or oil heater connection.
11. Check and record engine oil level, radiator water level, and battery electrolyte level.
12. Piping System Tests: Complete system test in accordance with the respective section.
13. Inspect the installation and access/clearance for service and maintenance to ensure it meets the project and manufacturer's requirements.
14. Check lubricating oil for lubricated-type equipment.
15. Check for proper seismic restraints.
16. Check that safety valves have correct setting; greater than compressor discharge pressure, but not greater than pressure rating of system components.
17. Check that all operating controls are set for initial safe operation.

C. Start-Up Tests: During startup, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
1. Tested generator at 50, 75, 100 percent load capacity using load banks at 100 percent power factor.
2. Run load test at all loads for 30 minutes recording engine and alternator readings at the start, at 15 minutes and at 30 minutes.
3. Simulate operation of all generator safeties such as high oil pressure, low oil pressure, high temperature, over speed, etc. Observe function of safeties under actual malfunction situation.
4. Check for excessive vibration and noise. Correct problems.

D. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

3.06 LIGHTING CONTROLS

A. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

B. Start-Up Checks: During startup, perform the following checks and any additional checks specified in manufacturer's instructions.
1. Ensure all labeling for all relays/contactors is affixed and accurate.
2. Ensure all terminations are tight.
3. Check sensor placement is adequate for required duty.
4. Ensure adequate access is provided to all relays/contactors, timeclocks, etc.
5. Ensure all circuits for the loads are energized and ready for testing.
6. Obtain all time schedules and individual device time-delay settings for all spaces from the Owner.

C. Start-Up Tests: During startup, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
1. Test, calibrate, and set all sensing (photocells, motion sensors, etc.) devices.
2. Verify the correct operation of all control devices (contactors, relays, timeclocks, BAS interface relays, etc.).
3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.
4. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is properly sized.
5. Enter all time schedules per Owner's direction. Individual device time-delay settings are handled as part of the Room/Zone Checkout described in this Section.
6. Validate all interfaces with other systems on a point-by-point basis.

D. Training: Train Owner's maintenance personnel on the operation, programming and maintenance of the lighting controls.

3.07 INTEGRATED LIGHTING CONTROL SYSTEMS

A. General: Provide the services of a factory-trained manufacturer's representative to assist the contractor in the installation and start-up service of the lighting control system and train Owner's maintenance personnel as specified below. Representative will confirm the proper installation and operation of all system components. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

B. Start-Up Checks: During startup, perform the following checks and any additional checks specified in manufacturer's instructions.
   1. Ensure all labeling is affixed and accurate.
   2. Ensure all terminations are tight.
   3. Check sensor placement is adequate for required duty.
   4. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
   5. Ensure all circuits for the loads are energized and ready for testing.
   6. Obtain all time schedules, individual device time-delay settings for all spaces, and on/off fade-rate settings from the Owner.

C. Start-Up Tests: During startup, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
   1. Test, calibrate, and set all digital and analog sensing, and actuating devices. Calibrate each instrumentation device by making a comparison between the graphic display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the Start-Up Report.
   2. Check each digital control point by making a comparison between the control command at the control panel and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device in the BAS Start-Up Report.
   3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.
   4. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is properly sized.
   5. Enter all time schedules, override time-delays and on/off fade rates per Owner's direction.
   6. For Operator Interfaces:
      a) Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
      b) Output all specified reports for review and approval.
      c) Verify the alarm printing and logging is functional and per requirements.
   7. Validate all interfaces with other systems on a point-by-point basis.

D. Training: Train Owner's maintenance personnel on the operation and programming of the lighting control system. Two days of training will be provided for up to 50 users.

3.08 ELECTRIC DISTRIBUTION POWER MONITORING SYSTEM

A. General: Provide the services of a manufacturer's certified specialist to supervise the installation, make adjustments, and perform tests on the Power Monitoring System and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

B. Start-up checklists: Perform the following final checks before startup
   1. Ensure all labeling is affixed and accurate
   2. Ensure all terminations are tight.

3. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
4. Review that all field input and output devices as shown on the construction drawings and shop drawings are installed.
5. Check wire supervision on all devices.

C. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:
1. Check location of all sensors and switches to ensure conformance with requirements.
2. Cause activation of all devices and confirm that associated alarms and/or control sequences are initiated and verify that resulting information displayed on the Power Monitoring System is per the requirements.
3. Verify interfaces with all other inter-related systems.
4. For annunciator panels, validate correct graphic and correct identification of all zones. Test the action and interlocks of all override switches as appropriate
5. For Operator Interfaces:
   a) Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
   b) Output all specified reports for review and approval.
6. Verify the alarm printing and logging is functional and per requirements
7. Validate all interfaces with other systems on a point by point basis

D. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

E. Review data in Operating and Maintenance Manuals.

- END OF SECTION 26 08 00 -

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor occupancy and vacancy sensors.
2. Switchbox-mounted vacancy sensors
3. Lighting contactors.
4. Generator Transfer Devices (internal and external type).

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

   a. Occupancy sensors.
   b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.
4. Floor plans with all sensor locations and associated coverage patterns. Sensor layouts displayed on drawings are product specific to basis of design. Alternative manufacturers submitting on project are allowed to submit their own sensor layout for review and approval based on their specific coverage patterns. Quantities may vary from manufacturer to manufacturer.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

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

1.6 ADDITIONAL MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Refer to drawings for any additional materials listed, and additionally provide the following:

1. Wall Mounted Occupancy Sensors – Provide 10 additional units and associated power packs.
2. Ceiling Mounted Occupancy Sensors (dual tech) – Provide 20 additional units and associated power packs.
3. Ceiling Mounted Occupancy Sensors (ultrasonic for hallways) – Provide 20 additional units (powered via BLC, verify with manufacturer if associated power packs required).
4. Ceiling Mounted Vacancy Sensors – Provide 30 additional units (powered via room controllers so no additional power packs required for this type).
5. Vacancy Sensor Switch Combo units – Provide 10 additional units (neutral required).

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY AND VACANCY SENSORS

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

1. Eaton Controls.
2. Wattstopper/Legrand
3. Acuity Controls/Sensor Switch.

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Passive infrared Ultrasonic Dual technology.
3. Separate power pack.
4. Hardwired connection to switch in stand-alone rooms.
5. Low voltage connections via networked lighting control panels.
6. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. 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 30 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 30 minutes.
c. Combination Sensor: Unless otherwise indicated, sensor shall 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 30 minutes.

8. Sensor Output: Sensor is powered from the power pack.
9. Power Pack: Dry contacts rated for 20-A ballast LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Power Failure memory:
    a. Controls incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and parameters saved in protected memory shall not be lost.
    b. Designed and tested to withstand discharges without impairment of performance when subjected to dischargers of 15,000 volts per IEC 801-2.
11. 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.

12. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
13. Bypass Switch: Override the "on" function in case of sensor failure.
14. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
15. All sensors shall have readily accessible, user adjustable settings for time delay and sensitivity. Settings shall be located on the sensor (not the control unit) and shall be recessed to limit tampering.

C. PIR Type: Wall or Ceiling mounted; detect occupants in coverage area by their heat and movement.

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, Ceiling Mounted): Detect occupancy anywhere in a circular area of 2000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
4. Extreme Temperature PIR types shall have operating temperatures from -40deg F to 125d F. UL Listed for damp locations. Temperature compensating circuitry to avoid false activation in extreme conditions, segmented frosted lens, Immune to RFI, EMI and voltage fluctuations.

D. Ultrasonic Type: Wall or 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 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

2. Utilize Doppler shift ultrasonic detection technology.
3. 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.
4. Detection Coverage (Corridor): Detect occupancy anywhere within 80 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).
5. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet (220 square meters) when mounted84 inches (2100 mm) above finished floor.

E. Dual-Technology Type: Wall of 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- (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. Incorporate Doppler shift ultrasonic and passive infrared motion detection technologies. Products that react to noise or ambient sound shall not be considered.

F. Vacancy Wall Switches:
1. Requires manual On to activate lighting.
2. Provide a mechanical air-gap on/off function for all sensors.
3. Capable of detection of occupancy at desktop level up to 300 square feet, and gross motion up to 1000 square feet.
4. Shall accommodate loads from 0-800 watts at 120 volts; 0 to 1200 watts at 277 volts and shall have 180 degree coverage capability.
5. Shall be able to have their visible plastic parts replaced, for color changes in the field, without removing the body of the control from the wall and without requiring special tools.
6. Shall have no leakage current to load, in manual or in Auto/Off mode for safety purposes and shall have voltage drop protection.
7. Shall be dual technology.
8. A Neutral shall be required.
9. Where specified as dual relay, provide two separate buttons, one for lighting, one for motor load. Each relay can be set independently to automatic or manual on mode. Motor load relay rated for 1/4hp minimum. Motor load relay shall have adjustable time delay for 10 minutes minimum after no detection.
10. Shall have adjustable time delay.
11. Shall have self-adaptive technology.

2.2 DIGITAL WALL SWITCH FOR CORRELATED COLOR TEMPERATURE (CCT)

A. Digital CCT Preset Switch for control of Correlated Color Temperature (CCT) in a room require fixtures with below listed CCT capable Logic Module with DLM Control Card - 1 per each independent lighting orientation (eg. direct and indirect), and circuit feed, up to a maximum 8 foot linear LED array or 2 individual down lights. Logic Module characteristics are determined by the specific module installed (Blanco 1, Blanco 2, Blanco 3, or Araya 5) and the LED array.

Adjustment of CCT shall precisely trace the Black Body Curve across the LED array's tunable range to replicate natural daylight within the built environment. Only white LED's shall be used for maximum efficacy except for Araya 5. Lighting Fixtures, Lamps, and Ballasts are specified in Section 16500.

B. Each Logic Module with a DLM Control Card to be individually addressable by the system. All other DLM hardware and software products will treat the combo Logic Module/DLM Control Card as a single DLM load and a single DLM device, with the capability of controlling them individual or as part of a group with other DLM load devices in the space, or over the room-to-room network.

C. CCT functionality to be implemented as an additional channel of information for any DLM load device. DLM's standard system capabilities to apply without reduction - either a max of 24, 48, or 96 DLM devices on the local network based on the power device, and a max of 64 loads. Loads that are not CCT capable will ignore any CCT command, so that CCT loads can be added to any existing DLM network without problem to existing programming and devices.

D. CCT and minimum CCT level determined by specific version of logic module used:

1. Blanco 1 - No CCT capability, but dimming to .1% minimum.
2. Blanco 2 - 2 Channel CCT and dimming to .1% minimum. CCT range from 3000 - 5000K unless specified differently in the fixture schedule.
3. Blanco 3 - 3 Channel CCT and .1% minimum dimming level. CCT range from 2700 - 6500K.
4. Araya 5 - 5 Channel CCT and 1% minimum dimming level. CCT range from 1650 - 8000K.

5. CRI shall not be less than 90 (85 for Araya 5) throughout the entire CCT range.

6. Color consistency of =2 MacAdam ellipses over the life of the source.

7. Closed loop thermal and optical feedback to compensate for thermally induced output variation and lumen depreciation over time.

8. Integrated driver and LED array assemblies to address inherent LED variability and complex non-linear relationships between system components.

9. A unique, programmable color model for each color tuning light source enabled by in-line dynamic spectral capture of each LED and custom color model generation.

E. Low voltage CCT Preset Switch shall include the same hardware features specified in the preceding paragraph Digital Wall Switches and be connected to the room's DLM Cat 5e local network cable.

5 Button CCT Preset Switch to control CCT capable loads via its 4 buttons and rocker.

1. Default Plug n' Go behavior will be that the Preset Switch will bind to all CCT capable loads in the room on connection. Individual loads can be added or removed via normal Push n' Learn programming either manually, via hand held commissioning tool, or LMCS software.
2. The four preset buttons provide default settings of 100%, 75%, 50% and 25% of available CCT range. Buttons can be programmed to a user's preferred presets by specifying a specific Kelvin temperature, or DLM percentage of controlled fixtures' CCT range (0-100%). Pressing and holding preset button for 5 seconds to record new preset level to that button based on last changed fixture's current setting.

3. CCT Present Switch shall also include a single rocker that provides full range control of all bound load's CCT level.

F. Main override button to be capable of any one of the following:

G. Control intensity of all assigned CCT loads On/Off, or

H. Ability to override CCT level and automatically resume schedule after timed override expires, or ability to override CCT level and manually resume schedule

2.3 GENERATOR TRANSFER DEVICES:

A. Internal type (for single luminaire):
1. Shall be UL924 listed equal to Bodine model GTD or approved equals rated for 120 through 277 volts AC and up to 3 amperes of lighting load. Device shall be self contained, modular unit mounted within luminaire body, capable of bypassing the local switching means when normal utility power has been lost. Including disconnection of any dimming functions allowing luminaire to return to full brightness.
2. Device will consist of a test switch, normal power indicator light and alternate power indicator light.

B. External type (controlling multiple Luminaires):
1. Shall be UL924 listed equal to Bodine GTD20A or approved equals rated for 120 through 277 volts AC and up to 20 amperes of lighting load. Device shall be self-contained, modular unit mounted above accessible ceiling, capable of bypassing the local switching means when normal utility power has been lost. Including disconnection of any dimming functions allowing luminaire to return to full brightness.
2. Device will consist of a test switch, normal power indicator light and alternate power indicator light and device. No remote test switch/cover plates will be allowed.

2.4 LIGHTING CONTACTORS

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

1. Eaton.
2. General Electric Company.

B. Description: Electrically operated and mechanically electrically held, combination-type lighting contactors with fusible switch non-fused 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 THD 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 matching the NEMA type specified for the enclosure.

2.5 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "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 Section 260519 "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 Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. 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 systems, and partition assemblies and per shop drawings.

D. 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.

E. 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.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch (21-mm).

B. Wiring within Enclosures: 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.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within twenty-four (24) months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to four (4) visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Submit written documentation of completion.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Provide at least two field visits for 4 hours of training each.

- END OF SECTION 26 09 23 -

SECTION 26 09 26
LIGHTING CONTROL PANELS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Distributed Digital Lighting Control System: System includes

1. Digital Lighting
2. Relay Panels
3. Emergency Lighting Control.

1.2 RELATED SECTIONS

A. Section 262726 – Wiring Devices.

B. Section 260923 – Lighting Control Devices: Occupancy/Vacancy sensors used in conjunction with the lighting control system.

1.3 REFERENCES

A. NFPA 70 - National Electrical Code; National Fire Protection Association.

B. NEMA - National Electrical Manufacturers Association

C. FCC emission standards

D. UL - Underwriters Laboratories, Inc. Listings

E. UL 2043 - Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products Installed in Air-Handling Spaces.

F. UL 20 - General Use Switches, Plug Load Controls

G. UL 924 - Standard for Emergency Lighting and Power Equipment

H. ULC - Underwriter Laboratories of Canada Listings

1.4 DESIGN / PERFORMANCE REQUIREMENTS

A. Digital Lighting Management System shall accommodate the square-footage coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors, switches, daylighting sensors and accessories that suit the required lighting and electrical system parameters.

B. System shall conform to requirements of NFPA 70.

C. System shall comply with FCC emission standards specified in part 15, sub-part J for commercial and residential application.

D. System shall be listed under UL sections 916 and/or 508.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

B. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Catalog sheets and specifications.
   2. Ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
   3. Storage and handling requirements and recommendations.
   4. Installation instructions.

C. Shop Drawings: Wiring diagrams for the various components of the System specified including:
   1. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed.
   2. Show location of all devices, including at minimum sensors, load controllers, and switches/dimmers for each area on reflected ceiling plans.
   3. Provide room/area details including products and sequence of operation for each room or area. Illustrate typical acceptable room/area connection topologies.

D. Manufacturer's Certificates: Certify products meet or exceed specified requirements.

E. Closeout Submittals:
   1. Project Record Documents: Record actual installed locations and settings for lighting control devices.
   2. Operation and Maintenance Manual:
      a. Include approved Shop Drawings and Product Data.
      b. Include Sequence of Operation, identifying operation for each room or space.
      c. Include manufacturer's maintenance information.
      d. Operation and Maintenance Data: Include detailed information on device programming and setup.
      e. Include startup and test reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing of centralized and distributed lighting control systems with a minimum of 10 years documented experience.

B. Installer Qualifications: Company certified by the manufacturer and specializing in installation of lighting control products with minimum three years documented experience.

C. System Components: Demonstrate that individual components have undergone quality control and testing prior to shipping.

1.7 PRE-INSTALLATION MEETINGS

A. Convene minimum two weeks prior to commencing Work of this section. Meeting to be attended by Contractor, Architect, system installer, factory authorized manufacturer's representative, and representative of all trades related to the system installation.

B. Review installation procedures and coordination required with related Work and the following:
   1. Confirm the location and mounting of all devices, with special attention to placement of switches, dimmers, and any sensors.
   2. Review the specifications for low voltage control wiring and termination.
   3. Discuss the functionality and configuration of all products, including sequences of operation, per design requirements.
   4. Discuss requirements for integration with other trades

C. Inspect and make notes of job conditions prior to installation:
   1. Record minutes of the conference and provide copies to all parties present.

2. Identify all outstanding issues in writing designating the responsible party for follow-up action and the timetable for completion.
3. Installation shall not begin until all outstanding issues are resolved to the satisfaction of the Architect.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation

1.9 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

B. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
1. Ambient temperature: 32 to 104 degrees F (0 to 40 degrees C).
2. Relative humidity: Maximum 90 percent, non-condensing.

1.10 WARRANTY

A. Products Warranty: Manufacturer shall provide a 5 year limited warranty on products within this installation, except where otherwise noted, and consisting of a one for one device replacement.

1.11 ADDITIONAL 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. Room Controllers (classrooms) – Provide 1 for every 10 classrooms.
2. Room Controllers (all other spaces) – Provide 1 for every 20 similar spaces. Furnish at least one of each type labeled as per room being served.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer: Wattstopper/Legrand or subject to compliance and prior approval with specified requirements of this section, by one of the following:

1. Eaton Lighting Systems
2. Acuity Brand N Light.

2.2 DISTRIBUTED DIGITAL LIGHTING CONTROL SYSTEM

A. Equipment Required: Lighting Control and Automation system as defined under this section covers the following equipment.

1. Digital Lighting Management (DLM) local network: Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.
2. Digital Occupancy Sensors: Self-configuring, digitally addressable, calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.
3. Digital Switches: Self-configuring, digitally addressable pushbutton on/off, dimming, and scene switches with two-way active infrared (IR) communications.

4. Handheld remotes for personal control: On/Off, dimming and scene remotes for control using infrared (IR) communications. Remote may be configured in the field to control selected loads or scenes without special tools.
5. Digital Daylighting Sensors: Single-zone open loop daylighting sensors with two-way active infrared (IR) communications for daylight harvesting using switching, bi-level, tri-level or dimming control.
6. Digital Lighting Management Relay Panel and Zone Controller: Provides up to 8, 24, or 48 mechanically latching relays. Relays include a manual override and a single push-on connector for easy installation or removal from the panel. Panel accepts program changes from handheld configuration tool for date and time, location, holidays, event scheduling, button binding and group programming.
7. Emergency Lighting Control Unit (ELCU): Allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building

B. Local Network LMRJ-Series: DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building.

1. Features of the DLM local network include:

   a. Plug n' Go automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
   b. Simple replacement of any device in the local DLM network with a standard off the shelf unit without requiring significant commissioning, configuration or setup.
   c. Push n' Learn configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
   d. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

2. Digital room devices connect to the local network using pre-terminated Cat 5e cables with RJ-45 connectors, which provide both data and power to room devices. Systems that utilize RJ-45 patch cords but do not provide serial communication data from individual end devices are not acceptable.
3. If manufacturer's pre-terminated Cat5e cables are not used for the installation each cable must be individually tested and observed by authorized service representative following installation.

2.3 DIGITAL LOAD CONTROLLERS (ROOM CONTROLLERS)

A. Digital Load Controllers: Digital controllers for lighting zones, fixtures and/or plug loads automatically bind room loads to the connected control devices in the space without commissioning or the use of any tools. Provide controllers to match the room lighting and plug load control requirements. Controllers are simple to install, and do not have dip switches/potentiometers, or require special configuration for standard Plug n' Go applications. Control units include the following features

1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
2. Simple replacement using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf device.
3. Multiple room controllers connected together in a local network must automatically

arbitrate with each other, without requiring any configuration or setup, so that individual load numbers are assigned starting with load 1 to a maximum of 64, assigned based on each controller's device ID's from highest to lowest.

4. Device Status LEDs to indicate:

    a. Data transmission
    b. Device has power
    c. Status for each load
    d. Configuration status

5. Quick installation features including:

    a. Standard junction box mounting
    b. Quick low voltage connections using standard RJ-45 patch cable

6. Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:

    a. Turn on to 100 percent
    b. Turn off
    c. Turn on to last level

7. Each load be configurable to operate in the following sequences based on occupancy:

    a. Auto-on/Auto-off (Follow on and off)
    b. Manual-on/Auto-off (Follow off only)

8. Polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.
9. UL 2043 plenum rated
10. Manual override and LED indication for each load
11. Zero cross circuitry for each load
12. All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.
13. Dimming Room Controllers shall share the following features:

    a. Fade rates for dimming loads shall be specific to bound switch buttons, and the load shall maintain a default value for any bound buttons that do not specify a unique value.
    b. The following dimming attributes may be changed or selected using a wireless configuration tool:

        1) Establish preset level for each load from 0-100 percent
        2) Set high and low trim for each load

    c. Override button for each load provides the following functions:

        1) Press and release for on/off control
        2) Press and hold for dimming control

    d. Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected ballast or driver. LED level indicators on bound dimming switches shall utilize this new maximum and minimum trim.
    e. Each dimming output channel shall have an independently configurable minimum

and maximum trim level to set the dynamic range of the output within the new 0-100 percent dimming range defined by the minimum and maximum calibration trim.

f. Calibration and trim levels must be set per output channel. Devices that set calibration or trim levels per controller (as opposed to per load) are not acceptable.

g. All configuration shall be digital. Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.

2.4 DIGITAL DAYLIGHTING SENSORS

A. Digital daylighting sensors shall work with load controllers and relay panels to provide automatic switching, bi-level, or tri-level or dimming daylight harvesting capabilities for any load type connected to the controller or panel. Daylighting sensors shall be interchangeable without the need for rewiring.

1. Closed loop sensors measure the ambient light in the space and control a single lighting zone.
2. Open loop sensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones.
3. Dual loop sensors measure both ambient and incoming daylight in the space to insure that proper light levels are maintained as changes to reflective materials are made in a single zone

B. Digital daylighting sensors shall include the following features:

1. Sensor's internal photodiode shall only measure lightwaves within the visible spectrum. The photodiode's spectral response curve shall closely match the entire photopic curve. Photodiode shall not measure energy in either the ultraviolet or infrared spectrums. Photocell shall have a sensitivity of less than 5 percent for any wavelengths less than 400 nanometers or greater than 700 nanometers.
2. Sensor light level range shall be from 1-6,553 foot-candles (fc).
3. Capability of ON/OFF, bi-level or tri-level switching, or dimming, for each controlled zone, depending on the selection of load controller(s) and load binding to controller(s).
4. For switching daylight harvesting, the photosensor shall provide a field-selectable deadband, or a separation, between the "ON Setpoint" and the "OFF Setpoint" that will prevent the lights from cycling excessively after they turn off.
5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a field-selectable minimum level.
6. Photosensors shall have a digital, independently configurable fade rate for both increasing and decreasing light level in units of percent per second.
7. Photosensors shall provide adjustable cut-off time. Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns off. Selectable range between 0-240 minutes including option to never cut-off.
8. Integral infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
9. Configuration LED status light on device that blinks to indicate data transmission.
10. Status LED indicates test mode, override mode and load binding.
11. Recessed switch on device to turn controlled load(s) ON and OFF.
12. BACnet object information shall be available for the following daylighting sensor objects, based on the specific photocell's settings:

    a. Light level
    b. Day and night setpoints

c. Off time delay
d. On and off setpoints
e. Up to three zone setpoints
f. Operating mode - on/off, bi-level, tri-level or dimming

13. One RJ-45 port for connection to DLM local network.
14. A choice of accessories to accommodate multiple mounting methods and building materials. Photosensors may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox. Standard tube photosensors accommodate mounting materials from 0-0.62 inch thick (LMLS-400, LMLS-500). Extended tube photosensors accommodate mounting materials from 0.62 to 1.25 inches thick (LMLS-400-L, LMLS-500-L). Mounting brackets are compatible with J boxes (LMLS-MB1) and wall mounting (LMLS-MB2). LMLS-600 photosensor to be mounted on included bracket below skylight well.
15. Any load or group of loads in the room can be assigned to a daylighting zone
16. Each load within a daylighting zone can be individually enabled or disabled for discrete control (load independence).
17. All digital parameter data programmed into a photosensor shall be retained in non-volatile FLASH memory within the photosensor itself. Memory shall have an expected life of no less than 10 years.

2.5 LMCP LIGHTING CONTROL PANELS AND LMZC ZONE CONTROLLER

A. Hardware: Provide LMCP lighting control panels in the locations and capacities as indicated on the Drawing and schedules. Each panel shall be of modular construction and consist of the following components:

1. Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 - 8 relays, 1 - 24 relays and 6 four-pole contactors, or 1 - 48 relays and 6 four-pole contactors.
2. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. LMCP panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
3. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. Interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. Interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. Panel interiors shall include the following features:

a. Removable, plug-in terminal blocks with connections for all low voltage terminations.
b. Individual terminal block, override pushbutton, and LED status light for each relay.
c. Direct wired switch inputs associated with each relay shall support 2-wire momentary switches only.
d. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches; digital IO modules capable of receiving 0-5V or 0-10V analog photocell inputs; digital IO modules capable of receiving momentary or maintained contact closure inputs or analog sensor inputs; digital daylighting sensors; and digital occupancy sensors. Inputs are divided into two separate digital networks, each capable of supplying 250mA to connected devices.
e. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet.
f. Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.
g. Group and pattern control of relays shall be provided through a simple keypad

interface from a handheld IR programmer. Any set of relays can be associated with a group for direct on/off control or pattern (scene) control via a simple programming sequence using the relay override pushbuttons and LED displays for groups 1-8 or a handheld IR programmer for groups 1-99.

h. Relay group status for shall be provided through LED indicators for groups 1-8 and via BACnet for groups 1-99. A solid LED indicates that the last group action called for an ON state and relays in the group are on or in a mixed state.

4. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:

   a. Electrical:

      1) 30 amp ballast at 277V
      2) 20amp tungsten at 120V
      3) 1.5 HP motor at 120V
      4) 14,000 amp short circuit current rating (SCCR) at 347V

   b. Mechanical:

      1) Replaceable, 1/2 inch KO mounting with removable Class 2 wire harness.
      2) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
      3) Dual line and load terminals each support two #14 - #12 solid or stranded conductors.
      4) Tested to 300,000 mechanical on/off cycles.

5. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.
6. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.
7. Where indicated, lighting control panels designated for control of emergency lighting shall be provided with factory installed provision for automatic by pass of relays controlling emergency circuits upon loss of normal power. Panels shall be properly listed and labeled for use on emergency lighting circuits and shall meet the requirements of UL924 and NFPA 70 - Article 700. All emergency fixtures being dimmed under normal power shall go to full brightness.
8. Integral system clock shall provide scheduling capabilities for panel-only projects without DLM segment networks or BAS control.

   a. Each panel shall include digital clock capability able to issue system wide automation commands to up to 11 other panels for a total of 12 networked lighting control panels. Clock shall provide capability for up to 254 independent schedule events per panel for each of the ninety-nine system wide channel groups.
   b. Clock capability of each panel shall support the time-based energy saving requirements of applicable local energy codes.
   c. Clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and will include a battery back up for clock function and program retention in non-volatile FLASH memory. Clocks that require multiple events to meet local code lighting shut off requirements shall not be allowed.
   d. Clock capability of each panel shall operate on a basis of ON/OFF or Normal

Hours/After Hours messages to automation groups that implement pre-configured control scenarios. Scenarios shall include:

1) Scheduled ON / OFF
2) Manual ON / Scheduled OFF
3) Astro ON / OFF (or Photo ON / OFF)
4) Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)

e. User interface shall be a portable IR handheld remote control capable of programming any panel in the system
f. Clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.
g. Schedules programmed into the clock of any one panel shall be capable of executing panel local schedule or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost. Lighting control panels that are not capable of executing events independently of the global network shall not be acceptable.

9. Lighting control panel can operate as a stand-alone system, or can support schedule, group, and photocell control functions, as configured in a Segment Manager controller, via a segment network connection.
10. Lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 MS/TP-based using the BACnet protocol.

a. Panel shall have provision for an individual BACnet device ID and shall support the full 222 range (0 - 4,193,304). The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.
b. Panel shall support MS/TP MAC addresses in the range of 0 - 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.
c. Lighting control relays shall be controllable as binary output objects in the instance range of 1 - 64. The state of each relay shall be readable and writable by the BAS via the object present value property.
d. Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 - 64.
e. The 99 group Normal Hours/After Hours control objects associated with the panel shall be represented by binary value objects in the instance range of 201 - 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours mode. Commanding 0 or NULL shall put the relays into the after hours mode.
f. Setup and commissioning of panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:

1) Binary output objects in the instance range of 1 - 64 (one per relay) for on/off control of relays.
2) Binary value objects in the instance range of 1 - 99 (one per channel) for normal hours/after hours schedule control.
3) Binary input objects in the instance range of 1 - 64 (one per relay) for reading true on/off state of the relays.
4) Analog value objects in the instance range of 101 - 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5

shall activate the blink warn feature for the channel and set a 5-minute grace-time period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.

g. Description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.
h. BO and BV 1 - 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay in a way analogous to the BACnet Channel object described in addendum aa. (http://www.bacnet.org/Addenda/Add-135-2010aa.pdf)
i. Panel-aggregate control of relay Force Off at priority 2 shall be available via a single BV5 object. Force On at priority 1 shall be available via a single BV4 object.
j. Lockout of all digital switch buttons connected to a given panel shall be command-able via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.

11. In addition to the LMCP Relay Panels, an LMZC Zone Controller panel shall be available for zero-relay applications. The panel is designed for applications where LMFC-011 Fixture Controllers or other distributed load controllers are used to switch and/or dim the controlled loads. Key similarities to and differences from the LMCP panel design shall include:

a. Use the same intelligence board as the LMCP relay panel.
b. Shall not include relay driver boards or relays.
c. Have a removable interior section to facilitate installation, and a Tub/Cover. Cover is for surface mounting applications only.
d. Tub shall have two interior KOs to allow installation of LMPB-100 Power Boosters. Each installed Power Booster can provide an additional 150 mA for either of the two available DLM local networks provided by the LMZC.
e. All programming and networking (whether DLM Local Network and/or Segment Network) capabilities in the LMZC Zone Controller shall be similar to capabilities for LMCP relay panels, except for functions designed for panel-mounted HDR relays.

12. To aid in project start up, if LMFC Fixture Controllers are connected to an LMZC Zone Controller, Plug n' Go automatic configuration will establish a unique sequence of operation so that all LMFC-controlled fixtures will turn on to 50 percent output when any digital occupancy sensor detects motion.

B. User Interface: Each lighting control panel system shall be supplied with at least one handheld configuration tool. As a remote programming interface the configuration tool shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. User interface shall have the following panel-specific functions as a minimum:

1. Button binding of digital switches to groups shall be accessible via the handheld IR remote and accomplished from the digital switch station.
2. Programming of panel location information shall be accomplished by the handheld IR remote and include at a minimum LAT, LON, DST zone, and an approximate city/state location.

2.6 EMERGENCY LIGHTING CONTROL DEVICES

A. Emergency Lighting Control Unit - A UL 924 listed device that monitors a switched or

dimmed circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:

1. 120/277 volts, 50/60 Hz, 20 amp ballast rating
2. Push to test button
3. Auxiliary contact for remote test or fire alarm system interface
4. Shall disconnect 0-10v control wiring turning light fixture to full brightness.

PART 3 - EXECUTION

3.1 PREPARATION

A. Do not begin installation until measurements have been verified and work areas have been properly prepared.

B. If preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

C. Verify that required pre-installation meeting specified in Part 1 of this specification has been completed, recorded meeting minutes have been distributed and all outstanding issues noted have been resolved prior to the start of installation.

3.2 INSTALLATION

A. Install system in accordance with the approved system shop drawings and manufacturer's instructions.

B. Install all room/area devices using manufacturer's factory-tested Cat 5e cable with pre-terminated RJ-45 connectors.
1. If fixtures have internal DLM Control Modules, ensure that they are also connected with Cat 5e cable.
2. Low voltage wiring topology must comply with manufacturer's specifications.

C. All line voltage connections shall be tagged to indicate circuit and switched legs.

D. Test all devices to ensure proper communication.

E. Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings. Adjust time delay so that controlled area remains lighted while occupied.

F. Provide written or computer-generated documentation on the configuration of the system including room by room description including:
1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.)
3. Load Parameters (e.g. blink warning, etc.)

G. Post start-up tuning - Adjust sensor time delays and sensitivities to meet the Owner's requirements 30 days from beneficial occupancy. Provide a detailed report to the Architect / Owner of post start-up activity.

H. Tighten all panel Class I conductors from both circuit breaker and to loads to torque ratings as marked on enclosure UL label.

I. All Class II cabling shall enter enclosures from within low-voltage wiring areas and shall remain within those areas. No Class I conductors shall enter a low-voltage area.

J. Run separate neutrals for any phase dimmed branch load circuit. Different types of dimming loads shall have separate neutral.

K. Verify all non-panel-based lighting loads to be free from short circuits prior to connection to room controllers.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Notify Architect, Lighting Designer and Manufacturer in writing a minimum of 3 weeks prior to system start-up and testing.

B. Tests and Inspections: Manufacturer's service representative shall perform the following inspections and prepare reports.
1. Verify Class I and II wiring connections are terminated properly by validating system performance.
2. Set IP addresses and other network settings of system front end hardware per facilities IT instructions.
3. Verify / complete task programming for all switches, dimmers, time clocks, and sensors.
4. Verify that the control of each space complies with the Sequence of Operation.
5. Correct any system issues and retest.

C. Provide a report in table format with drawings, or using a software file that can be opened in the manufacturer's system software including each room or space that has lighting control installed. Indicate the following:
1. Date of test or inspection.
2. Loads per space, or Fixture Address identification.
3. Quantity and Type of each device installed
4. Reports providing each device's settings.

3.4 DEMONSTRATION AND TRAINING

A. Before Substantial Completion, arrange and provide two separate training session (min. of 4 hours each) for Owner instruction period to designated Owner personnel. Set-up, starting of the lighting control system and Owner instruction includes:
1. Confirmation of entire system operation and communication to each device.
2. Confirmation of operation of individual relays, switches, and sensors.
3. Confirmation of system Programming, photocell settings, override settings, etc.
4. Provide training to cover installation, programming, operation, and troubleshooting of the lighting control system.

3.5 PRODUCT SUPPORT AND SERVICE

A. Factory telephone support shall be available at no cost to the Owner following acceptance. Factory assistance shall consist of assistance in solving application issues pertaining to the control equipment.

- END OF SECTION 26 09 26 -

SECTION 26 22 13
LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes:

1. Dry-Type Transformers for 600 V and below.
2. K-Factor Transformers.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, insulation class, sound ratings and performance for each type and size of transformer.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

B. Field quality-control reports.

C. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Conduct all tests and installation of equipment based on manufacturer's recommendations

B. UL Energy Verification Mark, indicating conformance with DOE 2016.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; by Schneider Electric; or a comparable product by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

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 use.

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.

D. Coils: Continuous windings without splices except for taps.

1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.

2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

C. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

D. Indoor Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.

a. Finish Color: Gray weather-resistant enamel.

E. Taps for Transformers:

1. 15kVA and Smaller: One 5 percent tap above normal full capacity.
2. 30kVA and larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity

F. Insulation Class, Smaller Than 15 kVA: 150 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

G. Insulation Class, 15 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

H. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

I. Wall Brackets: Manufacturer's standard brackets.

J. Sound-Level Requirements based on NEMA ST 20:

1. 9.00 kVA and Less: 40 dBA.
2. 9.01 to 50.00 kVA: 45 dBA.
3. 50.01 to 150.00 kVA: 50 dBA.
4. 150.01 to 3000.00 kVA: 55 dBA.

2.4 K-FACTOR TRANSFORMERS

A. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

B. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

C. Transformers shall be minimum K-13.

2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Division 03 and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. 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-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. Perform each visual, electrical test, and mechanical inspection as stated in NETA Acceptance Testing Specification. Certify compliance with ATS.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

B. Refinish painted surfaces damaged during construction. Paint shall match color of equipment.

- END OF SECTION 26 22 13 -

SECTION 26 24 13
SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Detail utility company's metering provisions with indication of approval by utility company.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, 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. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components 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. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.8 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and[temporary] HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
   b. Altitude: Not exceeding 6600 feet (2000 m).

1.9 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. 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 SWITCHBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; by Schneider Electric; or a comparable product by one of the following:

1. Eaton
2. General Electric Company.
3. Siemens Power Transmission & Distribution, Inc.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Nominal System Voltage: As indicated on the Contract Documents.

J. Main-Bus Continuous: As indicated on the Contract Documents.

K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

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."
b. 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."

L. Indoor Enclosures: Steel, NEMA 250, Type 1.

M. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

N. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

O. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If

separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

R. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Copper feeder circuit-breaker line connections.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
6. Tapered bus is available, and may be standard, from some manufacturers. Tapered bus may preclude future expansion of the switchboard or even the rearrangement of loads to accommodate load changes. Full-size bus throughout is recommended but can be modified to obtain a cost saving.
7. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

S. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 SURGE PROTECTION DEVICES

A. See Specification 264313: Surge Protection for Low Voltage Power Circuits, Section 2.2, Service Entrance.

2.4 OVERCURRENT PROTECTIVE DEVICES

A. 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. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings for circuit breaker frame sized 600A or larger::

    a. Instantaneous trip.

b. Long- and short-time pickup levels.
c. Long and short time adjustments.
d. Ground-fault pickup level, time delay, and I squared t response.

3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
4. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
5. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

B. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.8 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to [NECA 400] [NEMA PB 2.1].

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

3.2 INSTALLATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Install switchboards and accessories according to NEMA PB 2.1.

C. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

G. Install filler plates in unused spaces of panel-mounted sections.

H. Install overcurrent protective devices, surge protection devices, and instrumentation.

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

I. Install spare-fuse cabinet.

J. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:

   a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
   b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Switchboard will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

- END OF SECTION 26 24 13 -

SECTION 26 24 16
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. Power panelboards.
2. Life-Safety panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. 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.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.

4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Coordination Layout Drawings:

1. Provide floor plans at ¼” = 1’-0” scale, showing the following for review by the Engineer

a. Dimensioned layout showing mounting location of equipment, equipment outline and NEC clearances/workspaces with corresponding structural, mechanical and architectural elements.
b. Show major conduit feeder locations
c. Identify equipment on submitted plans.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "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.
3. Submit final versions of Panelboard Schedules after load balancing

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. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers: provide all spare circuit breakers as indicated in Contract Documents.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 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.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets. Refer to Contract Documents for configurations.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
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 12.

2. Mounting Height:

a. 84 inches (2.13 m) maximum.
b. Over 84 inches (2.13 m); Bottom edge, maximum of 4 inches (102 mm) above floor.

3. Hinged Front Cover: Entire front trim hinged to box with continuous piano hinge and with standard door within hinged trim cover with continuous piano hinge. Trims shall cover all live parts and shall have no exposed hardware.
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, 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.

F. Incoming Mains:

1. Location: Top or Bottom; as required.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

I. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards 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."

2.3 POWER PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; by Schneider Electric or comparable product by one of the following:

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.

B. Panelboards: NEMA PB 1, distribution type.

C. 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.

D. Mains: As indicated on Contract Documents.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; by Schneider Electric or comparable product by one of the following:

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. 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 for circuit-breaker frame sizes 400A and larger:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.

4) Ground-fault pickup level, time delay, and I squared T response.

4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
6. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
7. Subfeed Circuit Breakers: Vertically mounted.
8. MCCB Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
   e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
   f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.5 LIFE-SAFETY PANELBOARDS

A. Life-Safety (Emergency) Panelboards are fed on the load side of ATS-1.

B. Products: Subject to compliance with requirements, provide one of the following:

   1. Square D; by Schneider Electric; Mission Critical Circuit Breaker.
   2. Eaton; Cooper-Bussman Fusible Panelboard.
   3. General Electric Company; GE Energy Management - Electrical Distribution;
   4. Littlefuse
   5. Mersen

C. Selective Coordination:

   1. Life Safety Panelboards main overcurrent protective devices shall be selectively coordinated with all supply-side overcurrent protective devices per NEC Article 700.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1 and applicable sections of NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

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. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407/NEMA PB 1.1.

D. Equipment Mounting:

1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

I. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

J. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

K. Install filler plates in unused spaces.

L. Stub four 1-inch (25 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

M. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

A. Create a circuit directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door. Include the following information:

1. Clear description of type of load served: including room name and/or number.
2. Panelboard ratings: AIC rating, main bus ampacity, main circuit breaker or main lug ampacity.
3. Source panelboard and circuit number, incoming feeder size.
4. Panelboard room location and panelboard name.

B. Panelboard Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each panelboard, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

C. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. 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.

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

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 in approved Coordination Study Shop Drawing.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

- END OF SECTION 26 24 16 -

SECTION 26 26 53
ELECTRIC VEHICLE CHARGING EQUIPMENT - LEVEL 2

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 EV charging equipment that provides Level 2 EV charging.

1.3 DEFINITIONS

A. EV: Electric vehicle.

B. EV Cable: The off-board cable containing the conductor(s) to connect the EV power controller to the EV that provides both power and communications during energy transfer.

C. EV Capable: Parking spaces that include nearby termination of raceway (conduit) to a power source with sufficient electrical panel capacity designed for simultaneous charging of electric vehicles in all planned EV parking spaces. Electrical wiring need not be pulled through raceway (conduit) until charging station is installed.

D. EV Charger or EV Charging Equipment: See "EVSE".

E. EV Connector: A conductive device that, when electrically coupled to an EV inlet, establishes an electrical connection to the EV for the purpose of power transfer and information exchange. This device is part of the EV coupler.

F. EV Coupler: A mating EV inlet and connector set.

G. EV Inlet: The device in the vehicle into which the EV connector is inserted, and a conductive connection is made for the transfer of power and communication. This device is part of the EV coupler.

H. EV Make Ready: Parking spaces that include nearby termination of raceway (conduit) <u>and electrical wiring pulled</u> to a power source with sufficient electrical panel capacity for simultaneous charging of electric vehicles in all EV parking spaces.

I. EVSE: Electric Vehicle Supply Equipment. It includes the EV charging equipment and conductors, including the ungrounded, grounded, and equipment grounding conductors and EV cables, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for transferring energy between the premise wiring and the EV.

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 EV charging equipment.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Plan showing location and number of EV charging units, and distance from building.
2. Plan showing "reasonable accessibility" to EV charging units.
3. Plan showing location and number of EV charging units, charging levels and connectors, and ability of EV charging units to participate in a demand-response or time-of-use pricing program, as well as a power load management system that allows for an increased number of charging stations than would otherwise be feasible without power load management.
4. For electric vehicle supply equipment, documentation indicating:

   a. Charging capacity.
   b. Compliance with Society of Automotive Engineers (SAE) standard for electrical connectors.
   c. Confirmation of network control capabilities.

C. Shop Drawings: For EV charging equipment.

1. Include plans, elevations, sections, and mounting 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 mounting assemblies for EV charging equipment.
4. Include diagrams for power, signal, and control wiring.
5. Include verification of wireless communications service at each location of EV charging equipment.

D. Product Schedule: For EV charging equipment. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Area plans and 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. Structural members to which equipment will be attached.
2. Electrical service.
3. Communications service.

B. Qualification Data: For factory-authorized service representative.

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. Field quality-control reports.

E. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For EV charging equipment to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Online training and help documentation.
2. Station activation sticker.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

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

C. Comply with UL 2231-1. UL 2231-2, UL 2594, and NEC Article 625.

D. Comply with SAE J1772.

E. Comply with FCC Part 15 Class A.

1.8 FIELD CONDITIONS

A. Wireless Survey: Complete wireless survey to determine if wireless provider signals meet or exceed manufacturer's recommended minimum values.

B. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not exceeding minus 22 to plus 122 deg F (minus 30 to plus 50 deg C).
2. Altitude: Not exceeding 6600 feet (2000 m).

C. Rate Equipment for non-operation under the following conditions:

1. Ambient Temperature: Not exceeding minus 40 to plus 140 deg F (minus 40 to plus 60 deg C).
2. Altitude: Not exceeding 6600 feet (2000 m).

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of EV charging units that fail(s) in materials or workmanship within specified warranty period.
   1. Extended Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Provide ChargePoint CT4000 family of electric vehicle charging stations for commercial applications; and ChargePoint CPF25 family of electric vehicle charging stations for dedicated Fleet charging and multifamily resident personal charging applications.

B. Source Limitations: Obtain EV charging equipment from single manufacturer.

2.2 EV CHARGING EQUIPMENT DESCRIPTION

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 use.

B. Comply with NFPA 70.

C. ADA compliant.

D. Metering: +/- 2 percent from 2 percent to full scale of output (30 A).

E. EV Charging Equipment Mounting: Bollard mount.

F. Enclosures:

   1. Rated for environmental conditions at installed location.
      a. Indoor Locations: NEMA 250, Type 3R.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. Aluminum and UV-resistant plastic.
      d. Paint and Anodized.
      e. Charging components protected by security screws.
      f. Charging connectors in locking holsters.
      g. Meter, modem, and CPU, tamper resistant.

G. EV Cable and Connectors:

   1. SAE J1772 connector.
   2. Two connectors with locking holster.
   3. 18-foot (5.5 m)] [23-foot (7.5-m)] cable with cable management system.

H. Status Indicators:

   1. LEDs to indicate power, vehicle charging, charging complete, system status, faults, and service, as well as authorization.

I. Display Screen:

1. VGA-resolution, daylight-viewable LCD screen with UV protection. Daylight readable and fingerprint resistant.
2. Displays power, charging, charging complete, remote control, system status, faults, payment and pricing details, and service.

J. Networking:

1. WAN Communications: Cellular GSM/GPRS and CDMA.
2. LAN Communications: 2.4 GHz Wi-Fi 802.11b/g/n.
3. Capable of remote configuration, diagnostics and reporting.
4. Capable of remote software updates (future proof).

K. Payment System:

1. RFID (ISO 15693, ISO 14443), NFC, Contactless credit card reader.
2. PCI (Payment Card Industry) compliant.
3. Capable of remote control and authorization including mobile phone application or toll free phone number.

L. Charging Network: Compatible with the ChargePoint EV charging network.

1. Multiple units shall independently connect to charging network.
2. Multiple units shall have one unit designated as a master unit that is configured as a gateway unit between the EV charging equipment and the charging network.
3. Individual units shall be capable of indicating station status and availability providing or connecting user to customer support and remote control.

2.3 PERFORMANCE REQUIREMENTS

A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

B. Surge Withstand: 6 kV at 3000 A.

C. Integral GFCI.

D. Auto-GFCI fault retry.

E. Input Power:

1. Two 40 A, 208-V ac, 60 Hz, single phase per charger.
2. Dual circuits do not need to be interlocked.

F. EV Charging Levels:

1. Single vehicle: AC Level 2 at up to 7.2 kW (CT4000) or up to 7.7 kW (CPF25) per vehicle.
2. Dual vehicles, AC Level 2 at up to 7.2 kW (CT4000) or up to 7.7 kW (CPF25) per vehicle.
3. Multiple vehicles simultaneously charging at a site using Automatic Power Load Management may be charged up to 7.2 kW (CT4000) or up to 7.7 kw (CPF25) per vehicle.

2.4 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 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.

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 roughing-in for EV charging equipment electrical conduit to verify actual locations of conduit connections before equipment installation.

C. Examine walls, floors, and pavement for suitable conditions where EV charging equipment will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 413.

B. Concrete Base Mounting:

1. Install EV charging equipment on 6-inch (150-mm) nominal-thickness concrete base. Base should be 24-inch (600 mm) diameter or square (minimum 12-inch (300 mm) from the center located conduit stub-up). Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete".

    a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
    b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    d. Install anchor bolts to elevations required for proper attachment to supported equipment.
    e. Secure EV charging equipment to concrete base according to manufacturer's written instructions.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Wiring Method: Install cables in raceways and cable trays. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
2. Comply with requirements for underground raceways and enclosures specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems."

E. 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.

F. Circuit Breakers: Comply with Section 262816 "Enclosed Switches and Circuit Breakers."

G. Secure covers to enclosure.

3.3 CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Comply with grounding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

C. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

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-486B.

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. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. For each unit of EV charging equipment, perform the following tests and inspections:

   a. Unit self-test.
   b. Retain one of two operational tests below.
   c. Operation test with load bank.
   d. Operation test with EV.
   e. Network communications test.

D. EV charging equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

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 ONGOING MANAGEMENT SERVICES

A. Engage a station manufacturer that offers a service to manage the administration and policies of the electric vehicle charging stations on an ongoing basis.

3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for the duration of an active ChargePoint Network Service Plan.

B. Upgrade Service: At Substantial Completion, remotely update software to latest version. Install and program software upgrades that become available while an active ChargePoint Network Service Plan is maintained. Upgrading software shall include operating system and new or revised licenses for using software.

3.9 DEMONSTRATION

A. Utilize ChargePoint Station Management Services and ChargePoint Assure Services, or Train Owner's maintenance personnel to adjust, operate, and maintain EV charging equipment.

- END OF SECTION 26 26 53 -

SECTION 26 27 26
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. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. USB receptacles.
3. GFCI receptacles, 125 V, 20 A.
4. Controlled receptacles, 125V, 20A.
5. Cord and plug sets.
6. Toggle switches, 120/277 V, 20 A.
7. Wall-box dimmers.
8. Wall plates.

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.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

F. Finish Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Electrical System: RED.
3. Controlled Wiring Devices: GREEN.

G. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 MANUFACTURERS:

A. Basis-of-Design Product: Subject to compliance with requirements, provide Pass & Seymour/Legrand (Pass & Seymour); or a comparable product by one of the following:

1. Cooper Industries/Cooper Wiring Devices.
2. Hubbell Incorporated; Wiring Device-Kellems.
3. Leviton Manufacturing Co., Inc.

2.3 RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A; comply with UL 498, NEMA WD 1 and NEMA WD 6 configurations:

1. Convenience: 5362
2. Tamper-Resistant: TR5362
3. Tamper-Resistant USB: TR5362USB

a. Two (2) USB ports,
b. Minimum Charging Output: 3.1A.

4. Tamper-Resistant GFCI: 2095TR

a. Comply with UL 943, Class A
b. Integral self-testing with power denial technology
c. Minimum automatic self-test every: 3 seconds
d. Indicator light that is lighted when device is tripped.

5. Tamper- and Weather-Resistant GFCI: 2095TRWR

a. Weatherproof cover: WIUC 10-CL.

6. Tamper-Resistant Dual-Controlled Convenience: TR26352CD

a. Controlled receptacle marking permanently printed, molded or stamped on the face of the receptacle.
b. Markings comply with Article 406.3(E) of the 2014 National Electric Code.

2.4 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, 125 V, 20 A:

1. Configuration: NEMA WD 6, Configuration L5-20R.
2. Standards: Comply with UL 498.

2.5 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.

B. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R.

C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

E. Standards: Comply with FS W-C-596.

2.6 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 TOGGLE SWITCHES, 120/277 V, 20 A

A. Switches, 120/277V, 20A; comply with UL 20 and NEMA WD 1:

1. Single-Pole: PS20AC1
2. Three-Way: PS20AC3
3. Four-Way: PS20AC4
4. Key-Operated Single-Pole: PS20AC1-L
5. Key-Operated Three-Way: PS20AC3-L
6. Key-Operated Four Way: PS20AC4-L

2.8 DIMMERS

A. Wall-Box Dimmers:

B. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

C. Control: Continuously adjustable slider toggle switch; with single-pole or three-way switching. Comply with UL 1472.

D. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; 1200va rated, 0-10v dimming, rocker switch with slide dimmer, designed for LED power supplies, 3-way compatible, capable of consistent dimming with low end not greater than 10 percent of full brightness, flicker free. Leviton IP710-LF series or approved equals.

2.9 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, thermoplastic with lockable cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. 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 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 right 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 comply with NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that 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. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
5. Use a torque screwdriver when a torque is recommended or required by manufacturer.
6. Tighten unused terminal screws on the device.
7. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

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. 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.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for 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 unacceptable.
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. 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.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

- END OF SECTION 26 27 26 -

SECTION 26 28 13
FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

   a. Control circuits.
   b. Motor-control centers.
   c. Panelboards.
   d. Switchboards.
   e. Enclosed controllers.
   f. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data.

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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bussmann, an Eaton business.
2. Edison; a brand of Bussmann by Eaton.
3. Littelfuse, Inc.
4. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, time delay.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: Class J, time delay.
2. Motor Branch Circuits: Class RK1, time delay.
3. Other Branch Circuits: Class RK1, time delay.
4. Control Transformer Circuits: Class CC, time delay, control transformer duty.
5. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) as indicated in the field by Architect/Owner's Representative.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

- END OF SECTION 26 28 13 -

SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

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. 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.

1.8 FIELD 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).

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 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."

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. 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.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 MANUFACTURERS:

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; by Schneider Electric or comparable product by one of the following:

1. Eaton.
2. General Electric Company.

2.4 FUSIBLE SWITCHES

A. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Accessories (Required per device):

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. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Compression type, suitable for number, size, and conductor material.

C. Optional Accessories (As specified on Drawings):

1. Auxiliary Contact Kit: One NO/NC (Form “C”) auxiliary contact, arranged to activate before switch blades open. Contact rating – 120-V ac.
2. Service-Rated Switches: Labeled for use as service equipment.

2.5 NONFUSIBLE SWITCHES

A. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Accessories (Required per device):

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. Lugs: Compression type, suitable for number, size, and conductor material.

C. Optional Accessories (As specified on Drawings):

1. Auxiliary Contact Kit: One NO/NC (Form “C”) auxiliary contact, arranged to activate before switch blades open. Contact rating – 120-V ac.
2. Service-Rated Switches: Labeled for use as service equipment.

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

C. MCCBs shall be equipped with a device for locking in the isolated position.

D. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 100-A circuit breakers and below. 167 deg F (75 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.

E. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

F. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal 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.

G. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings for circuit breaker frame sizes 400A and larger:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

H. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One NO/NC contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock

mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

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.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 4X, stainless steel.
3. Kitchen, Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X, stainless steel.

3.3 INSTALLATION

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.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553 "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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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.

1. Visually and Mechanical inspect all equipment on project prior to installation.
2. Correct malfunctioning units on-site, with new units.

3.6 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 in approved Coordination Study Shop Drawing.

- END OF SECTION 26 28 16 -

SECTION 26 29 13
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.
3. Multispeed.

1.2 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers 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."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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. Comply with NFPA 70.

C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

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

a. Square D.
b. Eaton.
c. General Electric Company.

2. Configuration: Nonreversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Surface mounting.
5. Pilot light.
6. Hand-Off-Automatic selector switch.

C. Magnetic Controllers: Full voltage, across the line, electrically held.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Square D.

b. Eaton.
c. General Electric Company.

2. Configuration: Nonreversing.
3. Contactor Coils: Pressure-encapsulated type.

a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

6. Solid-State Overload Relay:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

7. External overload reset push button.

D. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Square D.
b. Eaton.
c. General Electric Company.

2. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
3. Nonfusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.2 MULTISPEED MAGNETIC CONTROLLERS

A. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Square D.
b. Eaton.
c. General Electric Company.

2. Configuration: Nonreversing; consequent pole or two winding.

3. Contactor Coils: Pressure-encapsulated type.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
6. Compelling relays shall ensure that motor will start only at low speed.
7. Decelerating timer relays shall ensure automatically timed deceleration through each speed.

8. Solid-State Overload Relay:

    a. Switch or dial selectable for motor running overload protection.
    b. Sensors in each phase.
    c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

9. External overload reset push button.

C. Combination Multispeed Magnetic Controller: Factory-assembled combination of multispeed magnetic controller, OCPD, and disconnecting means.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Square D.
    b. Eaton.
    c. General Electric Company.

2. Nonfusible Disconnecting Means:

    a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2.3 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4X, stainless steel.

2.4 ACCESSORIES

A. Push Buttons, Pilot Lights, and Selector Switches: NEMA ICS 5; heavy-duty type; factory installed in controller enclosure cover unless otherwise indicated.

1. Pilot Lights: LED type; red for “Power Available”, green for “Running”; push to test.

B. Control Relays: Auxiliary and adjustable time-delay relays.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings. Provide ICM controls ICM450 or approved equal, locate in separate enclosure at equipment; match NEMA enclosure rating with starter/disconnect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height, and with disconnect operating handles not higher than 79 inches (2006 mm) 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 at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in each fusible-switch enclosed controller.

D. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

E. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

F. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify enclosed controllers, 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 each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller 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.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify 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. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and overload-relay pickup and trip ranges.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

- END OF SECTION 26 29 13 -

SECTION 26 32 13.16
GASEOUS EMERGENCY ENGINE GENERATORS

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 engine generators for emergency use with the following features:

1. Natural gas engine.
2. Gaseous fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor engine generator enclosure.
7. Finishes.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.3 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. 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.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
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. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

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. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years comprehensive warranty, from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kohler Power Systems; or a comparable product by one of the following:

1. Cummins Power Generation.
2. Generac Power Systems, Inc.
3. MTU Onsite Energy Corporation.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components 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 when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: 1.5.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.

3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Certify EPA emissions

F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: **41 to 104 deg F (5 to 40 deg C)**
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to **1000 feet (300 m)**.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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 use.

C. Service Load: As indicated on Contract Documents.

D. Power Factor: 0.8, lagging.

E. Frequency: 60 Hz.

F. Voltage: 480-V ac.

G. Phase: Three-phase, four-wire wye.

H. Induction Method: Turbocharged.

I. Governor: Adjustable isochronous, with speed sensing.

J. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

K. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

L. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 ENGINE

A. Fuel: Natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent 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.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
3. 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.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

    1. Minimum sound attenuation of 25 dB at 500 Hz.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 24-V electric, with negative ground.

    1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" 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: Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice 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 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
    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 designed for nickel-cadmium batteries. 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 to 140 deg F (minus 40 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 10 percent.
        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.

2.5 GASEOUS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:

1. Natural Gas, Vapor-Withdrawal System:

   a. Carburetor.
   b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
   c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.

2. Fuel Filters: One for each fuel type.
3. Manual Fuel Shutoff Valves: One for each fuel type.
4. Flexible Fuel Connectors: Minimum one for each fuel connection.
5. Fuel change gas pressure switch.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run-time control set for 15 minutes, with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

E. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. 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.

1. Overcrank alarm.

2. Coolant low-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Lamp test.
16. Low-cranking voltage alarm.
17. Generator overcurrent-protective-device not-closed alarm.

F. 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.

G. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.

2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70 Article 700, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

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 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Instruments and control shall be mounted within enclosure.

1. Sound Attenuation Level: 75 dBA maximum sound level measured on all four sides of enclosure, at 23 feet (7 meters) with generator running at full load.

B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph (160 km/h).

C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Hinged Doors: With padlocking provisions.

E. Space Heater: Thermostatically controlled and sized to prevent condensation.

F. Lighting: Provide weather-resistant LED lighting with **30 fc (330 lx)** average maintained.

G. 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 components.

H. Muffler Location: Within enclosure.

I. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

   1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.

J. Interior Lights with Switch: Factory-wired, vaporproof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

   1. AC lighting system and connection point for operation when remote source is available.
   2. DC lighting system for operation when remote source and generator are both unavailable.

K. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

2.10 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator 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 and with IEEE 115.

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 for piping systems and electrical connections to verify actual locations of connections before packaged engine generator installation.

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

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators and remote radiators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and heat exchanger. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches (225 mm) of clearance from combustibles.
2. Insulate cooling-system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."

F. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

G. Gaseous Fuel Piping:

1. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
2. LP gas piping, valves, and specialties for gas piping are specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

G. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.
2) Inspect physical and mechanical condition.

3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Conduct performance test according to NFPA 110.
7) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery Tests: 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.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). 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.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations **25 feet (8 m)** from edge of the generator enclosure, and compare measured levels with required values.

D. Coordinate tests with tests for transfer switches and run them concurrently.

E. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

F. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

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

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

J. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

K. 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.

L. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels, so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 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 terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

- END OF SECTION 26 32 13.16 -

SECTION 26 36 00
TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less, including the following:

1. Automatic Transfer Switches

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 transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for transfer switches, 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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

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. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit 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.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be

mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

L. Neutral Terminal: Solid and fully rated unless otherwise indicated.

M. 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.

N. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable shrinkable sleeve markers at terminations. Color-coding and wire and cable 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.
4. Accessible via front access.

O. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kohler Power Systems; or a comparable product by one of the following:

1. Caterpillar, Inc.; Electric Power Division.
2. Cummins Power Generation.
3. Eaton.
4. Emerson.
5. Generac Power Systems, Inc.
6. General Electric Company.
7. MTU Onsite Energy Corporation.
8. Russelectric, Inc.

B. Comply with Level 1 equipment according to NFPA 110.

C. 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 unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.

5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Compression type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

G. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
4. Test Switch: Simulate normal-source failure.
5. Switch-Position Pilot Lights: Indicate source to which load is connected.
6. 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."

7. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
8. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
9. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
10. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.

11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown 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 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be 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 unavailable.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. 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.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:

    a. Overvoltage.
    b. Undervoltage.
    c. Loss of supply voltage.
    d. Reduction of supply voltage.
    e. Alternative supply voltage or frequency is at minimum acceptable values.
    f. Temperature rise.
    g. Dielectric voltage-withstand; before and after short-circuit test.
    h. Overload.
    i. Contact opening.
    j. Endurance.
    k. Short circuit.
    l. Short-time current capability.
    m. Receptacle withstand capability.
    n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
4. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, 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. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Route and brace conductors according to manufacturer's written instructions. Do not obscure manufacturer's markings and labels.

G. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

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. Manufacturer’s representative shall conduct all recommended tests and certify emergency power system is free from defects and works under normal operating conditions.

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.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

- END OF SECTION 26 36 00 -

SECTION 26 41 13
LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lightning protection system for the following:

1. Ordinary structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, coordinated with each other, using input from installers of the items involved:

B. Qualification Data: For Installer.

C. Product certificates.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Completion Certificate:

1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: LPI Master Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Advanced Lightning Technology, LTD.
2. East Coast Lightning Equipment Inc.
3. ERICO International Corporation.
4. Harger Lightning & Grounding.
5. Heary Bros. Lightning Protection Co. Inc.
6. Independent Protection Co.
7. National Lightning Protection.
8. Preferred Lightning Protection.
9. Robbins Lightning, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for school buildings.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for school buildings.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

1. Copper unless otherwise indicated.
2. 324 inches (610 mm) long.
3. Rounded tip.
4. Threaded base support.

B. Class 1 Main Conductors:

1. Stranded Copper: 57,400 circular mils in diameter.

C. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.

D. Ground Loop Conductor: Stranded copper.

E. Ground Rods:

1. Material: Solid copper.
2. Diameter: 3/4 inch (19 mm).
3. Rods shall be not less than 120 inches (3050 mm) long.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A and concealed systems in NFPA 780.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld.

C. 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.

3.3 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.

B. Prepare test and inspection reports and certificates.

C. Notify Architect at least 48 hours in advance of closing in section before concealing lightning protection components.

- END OF SECTION 26 41 13 -

SECTION 26 43 13
SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: twenty-five (25) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449, Type 2.

D. Comply with UL 1283.

E. Provide ten (10) dedicated modes of protection including Direct Line-to-Line. Provide three (3) Line-to-Neutral, three (3) Line-to-Ground, three (3) Line-to-Line and one (1) Neutral-to-Ground.

F. Provide the following features and accessories:

1. Dry contacts.
2. Audible alarm with alarm disable switch
3. Surge counter.

G. MCOV of the SPD shall be the nominal system voltage.

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide SSI, an ILSCO Company; or a comparable product by one of the following:

1. Advanced Protection Technologies Inc. (APT).
2. Current Technology Inc.
3. LEA International.
4. Liebert; a brand of Vertiv.

2.3 SERVICE ENTRANCE SUPPRESSOR

A. SPD shall be a multi-stage parallel protector. Please see one-line diagram and panelboard schedule to confirm voltages. SPD's minimum surge current capacity shall be

1. 300kA per phase (L-N plus L-G)
2. 100kA per mode (L-N, L-G, L-L, N-G)

B. SPD shall contain a technology that utilizes component-level and short circuit current fused metal oxide varistors (MOV) per mode.

C. Every component of every mode, including N-G, shall be internal thermally protected. SPDs relying upon external or supplementary installed safety overcurrent protection do not need intent of this specification.

D. All primary transient paths shall utilize copper wire, aluminum bus bar and lugs of equivalent capacity to provide equal impedance interconnection between phases. No plug-in module or components shall be used in surge carrying paths.

E. SPD shall be non-modular design.

F. If no circuit breaker is available add internal disconnect switch.

2.4 DISTRIBUTION PANEL SUPPRESSORS

A. SPD shall meet all specification requirements in Section 2.3 (B-F) and as follows:

1. SPD shall be a multi-stage parallel protector. Please see one-line diagram and panelboard schedule to confirm voltages. SPD's minimum surge current capacity shall be

   a. 180kA per phase (L-N plus L-G)
   b. 60kA per mode (L-N, L-G, L-L, N-G)

2.5 PANEL SUPPRESSORS

A. SPD shall meet all specification requirements in Section 2.3 (B-F) and as follows:

1. SPD shall be a multi-stage parallel protector. Please see one-line diagram and panelboard schedule to confirm voltages. SPD's minimum surge current capacity shall be

   a. 120kA per phase (L-N plus L-G)
   b. 40kA per mode (L-N, L-G, L-L, N-G)

2.6 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Damp or Wet Locations: NEMA 250, Type 4X.

C. Outdoor Enclosures: NEMA 250, Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground. Circuit breaker size is to be matched to SPD manufacturer wire size. Minimum circuit breaker size is 30A for connection means.

D. Wiring:

1. Tighten electrical connectors and terminals according to manufacturer’s published torque tightening values. If manufacturer’s torques values are not indicated, use those specified in UL 486A and UL 486B.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify per NEC 285.6 that the SPD AIC rating is equal or greater to the connecting equipment.
4. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
5. Perform visual and mechanical inspection of each unit to verify light functionality.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

- END OF SECTION 26 43 13 -

SECTION 26 51 19
LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. Interior solid-state luminaires that use LED technology.
b. Lighting fixture supports.

B. Related Requirements:

a. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
b. Section 260926 "Lighting Control Panelboards" for panelboards used for lighting control.

1.2 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, power supply/driver and housing.

H. Delivered Lumen: Measured light output exiting luminaire after all lensing reflector housing, etc.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

B. LEED SUBMITTALS: Comply with Section 018113

a. SS Credit 6: Light Pollution Reduction
b. For exterior luminaires, documentation indicating backlight, uplight, and glare ratings (BUG) rating.

C. Shop Drawings: For nonstandard or custom luminaires.

a. Include plans, elevations, sections, and mounting and attachment details.

b. Factory drawings for each variation of recessed and suspended linear lighting systems including lengths that are integral to continuous run with emergency functions in them. Submit factory drawing indicating which room each run is intended for.
c. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
d. Include diagrams for power, signal, and control wiring.

D. Substitutions:

a. Provide one luminaire for each substitution of product not listed in light fixture schedule. Sample luminaire shall be the specified color temperature, lumen output, correct size (i.e. 2x2 or 2x4), plug and cord installed on luminaire. Paint chip samples for non-standard colors shall be provided to Architect in size and quantity as required by Architect. Provision of sample does not imply approval of luminaire. All samples must be delivered (assembled and in working order) for inspection 10 days prior to bid with 5 days allocated for design team review/comment.

E. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of luminaire.

D. Sample warranty.

E. R9 values of LED Luminaires.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 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 year(s) from date of Substantial Completion.

1.7 ADDITIONAL MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Refer to drawings for any additional materials listed, and additionally provide the following:

a. Drivers: Provide 1 additional driver for every 25 luminaires of each type and rating installed. Furnish at least one of each type.
b. Lamps: Provide 1 additional led board (or module) for every 25 luminaires of each type and rating installed. Furnish at least one of each type.
c. Flat Panel Style LED luminaires: Provide 1 complete fixture for every 25 luminaires of each type and rating installed. Furnish at least one of each type.

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.

a. 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 for hazardous locations 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. Recessed Fixtures: Comply with NEMA LE 4.

E. CRI minimum of 80. CCT of 3500 Kelvin. unless otherwise noted on light fixture schedule.

F. Rated lamp life of 50,000 hours minimum at L70.

G. Dimmable from 100 percent to 10 percent of maximum light output minimum, flicker free and no cut outs (unless otherwise specifically noted in light fixture schedule for lower dimming range). All dimming controls shall be coordinated and confirmed with each light fixture manufacturer dimming driver prior to rough-in and confirmation indicated at shop drawing level in writing.

H. Internal driver. Bottom and/or room accessible when located in hard ceilings. No remote drivers unless specifically called for in light fixture schedule. All remote driver locations shall be submitted to architect for review and final approval prior to rough-in via floor plans at 1/8” scale indicating all locations and luminaires serving. Reverify all remote driver distances from luminaire with manufacturer recommendations and adjust wire size as required for normal operation. All class 2 wiring from a remote driver to luminaire shall be in conduit. Lutron Drivers shall not be accepted.

I. Nominal Operating Voltage: 120 V ac through 277 V ac (universal voltage) 12 V dc 24 V dc.

J. Housings:

a. Extruded-aluminum housing and heat sink.
b. Anodized powder-coat painted finishes. Finish per Architect.
c. All parts painted after fabrication

K. All interior Light Fixtures shall be DLC or Energy Star listed unless specifically noted in Light Fixture Schedule.

L. Refer to all Light Fixture Schedule General Notes.

2.3 RECESSED TROFFERS

A. Manufacturers: Subject to compliance with basis of design requirements (including DLC listings), provide products by one of the following:
a. H.E. Williams
b. Coronet Lighting
c. Eaton Lighting
d. LSI Industries
e. Mercury Lighting
f. Pinnacle Lighting
g. Or approved equals. Refer to 265119-1.3-C.

B. Minimum and/or Maximum lumens shall be per light fixture schedule.

C. With integral mounting provisions.

D. Bottom/Room side access.

E. 0 – 10V dimmable with isolated lead wires. Lutron Drivers shall not be accepted.

F. All parts painted after fabrication.

G. Spring loaded cam latch style for doors.

H. Volumetric style luminaires:
a. shall have their associated lens(es) extend from edge of housing to edge of housing with no gaps, visible hardware, visible sockets or led boards.
b. Side reflector(s) shall be smooth (no ribs, linear angles or prisms/beam modifiers, etc.) and flush to luminaire housing with no visible shadowing or gaps.

2.4 DOWNLIGHT

A. Manufacturers: Subject to compliance with basis of design requirements (including DLC/Energy Star listings), provide products by one of the following:
a. Atlantic Lighting.
b. Portfolio.
c. Spectrum Lighting.
d. Maxilume.
e. H.E. Williams.
f. Or approved equals. Refer to 265119-1.3-C.

B. Minimum lumens shall be per light fixture schedule. Minimum allowable efficacy of 68 lumens per watt.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

E. 0 – 10V dimmable with isolated lead wires. Lutron Drivers shall not be accepted.

F. Aluminum heat sink.

G. Self-flanged.

H. Gloves or other protective items shall be used when interacting with the reflector system. No finger prints, dirt, or oils shall be visible. Any indication of these shall require replacement of reflector system at no cost to manufacturer or owner.

2.5 RECESSED LINEAR

A. Manufacturers: Subject to compliance with basis of design requirements (including DLC listings), provide products by one of the following:
   a. Coronet Lighting.
   b. Nulite Lighting.
   c. Pinnacle Lighting.
   d. Mercury Lighting.
   e. Neoray Lighting.
   f. Or approved equals. Refer to 265119-1.3-C.

B. Minimum lumens per lighting fixture schedule.

C. Integral junction box with conduit fittings.

D. Integral 0–10v dimming driver with isolated lead wires. Lutron Drivers shall not be accepted.

E. Flush, snap in retention style Lensed (type as per light fixture schedule).

F. Refer to plans for housing lengths required. Continuous runs up to 8 ft. long shall be provided with one lens. Lengths over 8 ft. long up to 16 ft. long shall be provided with two lenses. Where two lenses meet, there will be no gap or light leak. Lensing at end of run shall not have more than 1/32 of an inch gap. Any indication of light leaks or exceeding indicated gap length at end of luminaire shall require replacement of lensing at no cost to owner. 4ft long lenses for Wall Wash style luminaires only will be acceptable.

G. Mounting hardware for each recessed linear luminaire run shall be coordinated with **all** other trades prior to ordering. Provide clearly defined submittal drawings indicating each location and associated hardware being provide at shop drawing level for every variation and run.

H. Extruded aluminum housing.

I. Refer to light fixture schedule General Notes.

2.6 STRIP LIGHT

A. Manufacturers: Subject to compliance with basis of design requirements (including DLC listings), provide products by one of the following:
   a. LSI.
   b. Metalux.
   c. H.E. Williams
   d. Mercury Lighting.
   e. Or approved equals. Refer to 265119-1.3-C.

B. Minimum lumens shall be per light fixture schedule.

C. Integral junction box with conduit fittings.

D. Aluminum housing with no plastic end caps.

E. Integral 0-10v dimming driver with isolated lead wires. Lutron Drivers shall not be accepted.

2.7 HIGH BAY

A. Manufacturers: Subject to compliance with basis of design requirements (including DLC listings), provide products by one of the following manufacturers:
   a. Atlantic Lighting.
   b. Venture Lighting.
   c. LSI.
   d. H.E. Williams.
   e. Or approved equals. Refer to 265119-1.3-C.

B. Minimum lumens shall be per light fixture schedule.

C. Acrylic lensing, bottom conical lens, wire guard with safety chain.

D. Mounting hardware submittals including power feed details, rigid suspension details, suspension points and attachment to structure.

E. Aluminum housing.

F. Integral 0-10v dimming driver with isolated lead wires. Lutron Drivers shall not be accepted.

2.8 SUSPENDED, LINEAR

A. Manufacturers: Subject to compliance with basis of design requirements (including DLC listings) provide products by one of the following manufacturers
   a. Coronet Lighting.
   b. Nulite Lighting.
   c. Pinnacle Lighting.
   d. Mercury Lighting.
   e. Neoray Lighting.
   f. Or approved equals. Refer to 265119-1.3-C.

B. Minimum lumens shall be per lighting fixture schedule.

C. Clear dust cover (where applicable).

D. Integral 0-10v dimming driver with isolated lead wires. Lutron Drivers shall not be accepted.

E. Mounting hardware submittals including power feed details, aircraft cable suspension details and suspension points.

F. Extruded aluminum housings.

G. Refer to plans for housing lengths required. Continuous runs up to 8 ft. long shall be provided with one lens. Lengths over 8 ft. long up to 16 ft. long shall be provided with two lenses. Where two lenses meet, there will be no gap or light leak. Lensing at end of run shall not have more than 1/32 of an inch gap. Any indication of light leaks or exceeding indicated gap length at end of luminaire shall require replacement of lensing at no cost to owner. 4ft long lenses for Wall Wash style luminaires only will be acceptable.

H. Flush, snap in retention style Lensed (type as per light fixture schedule).

I. Refer to light fixture schedule General Notes.

2.9 MATERIALS

A. Metal Parts:

a. Free of burrs and sharp corners and edges.
b. Sheet metal components shall be steel unless otherwise indicated.
c. 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:
a. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
b. Glass: Annealed crystal glass unless otherwise indicated.
c. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.10 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.

2.11 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. Single-Stem Hangers: 1/2-inch (13-mm) 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 (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) 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 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: Sized and rated for luminaire weight.

E. Flush-Mounted Luminaire Support: Secured to outlet box.

F. Wall-Mounted Luminaire Support:

a. Attached to structural members in walls Attached to a minimum 20 gauge backing plate attached to wall structural members Attached using through bolts and backing plates on either side of wall.
b. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

a. Ceiling mount with two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.
b. Ceiling mount with pendant mount four-point pendant mount with 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.
c. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

a. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
b. 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.
c. 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.
d. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

a. Secure to any required outlet box.
b. Secure luminaire using approved fasteners 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.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

a. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
b. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to generator power and retransfer too normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

D. At substation completion of project, for all Linear runs (recessed, surface or suspended); remove all lensing (direct and/or indirect) and clean lensing as directed by manufacturer removing all dust, debris, cable clippings, lose or exposed wiring, screws, etc. Re-install all lensing and verify compliance with Light Fixture Schedule General Noting.

- END OF SECTION 26 51 19 -

SECTION 26 56 13
LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Poles and accessories for support of luminaires.
2. Luminaire-lowering devices.

1.2 DEFINITIONS

A. EPA: Effective projected area.

B. Luminaire: Complete lighting fixture.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.3 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device.

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.

1.4 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. Seismic Qualifications for entire pole assembly.

C. Material test reports.

D. Field quality-control reports.

E. Sample warranty.

F. Soil test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data for luminaire maintenance and pole-mounted accessories.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(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.

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.

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 (2200 N) distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), 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 50 feet (15 m) high or less is 100 mph (45 m/s).

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. Per same manufacturer as luminaire.

B. Source Limitations: Obtain poles from single manufacturer or producer.

C. 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.

D. Poles: Comply with ASTM A 500/A 500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: Square straight.
2. Mounting Provisions: Bell bottom taper or approved equals. Minimum 0.75” base plate for bolted mounting on foundation
3. Provide internal barrier separation or internal raceway for security system cabling and low voltage 0-10v control wiring.

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 stainless or 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: Not allowed.

H. Fasteners: Stainless steel or 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 (13-mm) 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. Handhole: Oval or Rectangular shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws with independent access to both sides of barrier(s).

K. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch (76-by-130-mm) handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

L. 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.

M. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

N. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A 123/A 123M.

O. 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 from manufacturer's full range.

P. 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 from manufacturer's full range.

2.3 ALUMINUM POLES

A. Per same manufacturer as luminaire.

B. Poles: Seamless, extruded structural tube complying with ASTM B 221, Alloy 6063-T6, with access handhole in pole wall.

C. Poles: Seamed Seamless, extruded structural tube complying with ASTM B 221, Alloy 6061-T6, with access handhole in in pole wall.

1. Shape: Square straight.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
3. Provide internal barrier separation or internal raceway for security system cabling.

D. Mast Arms: Aluminum or Steel Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

E. 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 stainless or galvanized-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

F. Pole-Top Tenons: Not allowed.

G. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) 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 listed in that Section, and accessible through handhole.

H. Fasteners: Stainless steel or 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 to 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. Handhole: Oval or Rectangular shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

K. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" 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 of 0.018 mm or thicker), complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; 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.

L. 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 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, 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 from manufacturer's full range.

M. 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 to comply with 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 shall comply with AAMA 2604.

    a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: As selected by Architect from manufacturer's full range.

2.4 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

B. Transformer-Type Bases: Not allowed.

2.5 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi (380,000 kPa).

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
2. Threading: Uniform National Coarse 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.
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.
2. Two washers provided per anchor bolt.

2.6 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 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: not allowed.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than one-sixth of pole height as indicated. Add backfill in 6-inch (150-mm) to 9-inch (230-mm) layers, tamping each layer before adding the next as shown on Drawings. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: not allowed.

F. Anchor Bolts: Install plumb using manufacturer-supplied steel plywood template, uniformly spaced.

3.2 POLE INSTALLATION

A. 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."

B. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

C. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-(150-mm-) 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 (25 mm) below top of concrete slab.

D. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.3 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- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.4 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.

- END OF SECTION 26 56 13 -

SECTION 26 56 19
LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 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 260926 "Lighting Control Panelboards" for panelboard-based lighting control.
2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.2 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.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. LEED Submittals: Comply with Section 018113.
1. SS Credit 6: Light Pollution Reduction
   a. For Exterior Luminaires, documentation indicating backlight, uplight and glare ratings (BUG).

C. 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.

D. Substitutions:

1. Provide one luminaire for each substitution of product not listed in light fixture schedule. Sample luminaire shall be the specified color temperature, lumen output, plug and cord installed on luminaire (associated pole and or stanchion not required as a sample). Paint chip samples for non-standard colors shall be provided to Architect in size and quantity as required by Architect. Provision of sample does not imply approval of luminaire.

2. Point by Point calculations shall be done by the design team. Vendor or "others" provided photometrics will not be reviewed or approved. Submit appropriate IES file for:
   a. Each distribution type
   b. Correct lumen output
   c. As individual luminaire. Multiple heads on one pole shall be address by the design team.

E. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect and Lighting Designer prior to the start of luminaire installation.

B. Verify orientation and proper distribution with Lighting Designer prior to the start of luminaire installation.

1.7 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: Five (5) 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/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 IEC 60061-1.

F. CRI of minimum 70. CCT of 4000 Kelvin unless otherwise indicated in light fixture schedule.

G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 10 percent of maximum light output flicker free and no cut out.

I. Nominal Operating Voltage: 120 V ac 240 V ac 277 V ac 12 V dc 24 V dc.

J. In-line Fusing: Separate in-line fuse for each luminaire.

K. Integral 10kV rated surge suppression that is field replaceable.

L. Source Limitations: Obtain luminaires and associated pole from single source/from a single manufacturer.

M. 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 TYPES

A. Area and Site:
   1. Luminaire Shape: Per luminaire specifications. Refer to drawings.
   2. Mounting: Pole or Building.
   3. Luminaire-Mounting Height: Per drawing specifications. Secondary review shall be conducted with Architect and documented prior to rough-in for all wall mounted luminaires.
   4. Distribution: As specified in luminaire schedule.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum 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. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

E. 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.

F. Housings:

   1. Rigidly formed, weather and light-tight enclosure that will not warp, sag, or deform in use.

   2. U.L. listed for wet locations.

2.5 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.

    a. Color: Per Architect.

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 by Architect from manufacturer's full range.

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.

PART 3 - EXECUTION

3.1 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 to structural members in walls. Attached to a minimum 1/8 inch (3 mm) backing plate attached to wall structural members Attached using through bolts and backing plates on either side of wall. Refer to manufacturer installations recommendations and coordinate with Architect and Structural Engineer prior to rough-in.

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.

3.2 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- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

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. 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 all controls.

C. Illumination Tests:

1. Measure light intensities at night. Meter shall be placed on grade with no temporary or movable obstructions present. 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, measured lighting levels including weather conditions, day/month/year and at what time measurements taken and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and associated controls. Field training shall be a minimum of (2) Two Hours for controls training. Provide temporary sample of luminaire to demonstrate and train Owner's maintenance personal on luminaire at table top height (accessing components, replacement of led boards and drivers, surge suppressor replacement/maintenance).

B. Training personally shall be qualified and approved by the supplying luminaire manufacturer.

- END OF SECTION 26 56 19 -

SECTION 27 05 00
TELECOM PATHWAYS AND SPACES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Telecommunications Room Build Out

B. Pathways for Telecommunications Systems

C. Grounding and Bonding for Telecommunications

1.2 References

A. Industry Codes, Standards and Methods shall be observed, including the following:

1. ANSI/TIA-568-C.0: Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standard
3. ANSI/TIA-568-C.2: Balanced Twisted Pair Cabling and Components Standard
4. ANSI/TIA-568-C.3: Optical Fiber Cabling Components Standard
5. ANSI/TIA-569-B: Commercial Building Standard for Telecommunications Pathways and Spaces
6. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
7. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
8. ANSI-J-STD-607-A: Commercial Building Grounding and Bonding Requirements for Telecommunications
9. ANSI/TIA-758-A: Customer-Owned Outside Plant Telecommunications Cabling Standard
10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
11. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

B. Comply with all local, state and federal codes for telecommunications installations.

1.3 System Description

A. Design Requirements

1. Contractor shall outfit all telecom rooms according to T Drawings. Racks and other termination and distribution fields shall be installed according to manufacturer's guidelines and industry standards.
2. TR and TER layouts shall be approved by Technology personnel prior to installation of cabling, pathways or termination hardware.

B. Performance Requirements

1. Materials and equipment will be installed in an orderly and precise manner. Clearances between equipment will prevent incidental damage or unsafe conditions.

2. Equipment shall provide proper support and housing of all intended active and non-active components.

3. Refer to Telecom Room Details for precise location of equipment and termination fields.

1.4 Submittals

A. Product Data

1. Provide product data for all equipment listed in Part 2

2. Equipment data must be submitted in a single package and clearly indicated for efficient review. (by specifications section) Equipment submittals not clearly called out will be rejected without question at the contractor's expense for resubmittal.

3. Product data must be approved by designer and owner prior to purchase and installation of equipment.

4. LEED Submittals: Comply with Section 018113.

a. EQ Credit 2: Low-Emitting Materials

i. For interior wet-applied adhesives, sealants, paints, coatings: Documentation indicating compliance with California Department of Public Health (CDPH) Standard Method v1.1–2010 and VOC content in g/L. Include volume of material applied per product.

ii. For composite wood installed in building interior: Documentation indicating compliance with California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM), Phase II for ultra-low-emitting formaldehyde (ULEF) resins or containing no added formaldehyde resins.

B. Shop Drawings

1. Provide scaled drawings to show proposed equipment locations, clearances and administrative labeling of Telecom Rooms and equipment. All fields, racks and cabinets shall be methodically documented and permanently labeled agreed upon by school district.

2. Shop drawings must be approved by the designer and owner prior to purchase and installation of any equipment.

C. As-Built Drawings

1. Contractor shall upon completion of the project, provide a complete set of As-Built drawings. These drawings shall identify room numbers and outlet identification numbers for all low voltage cabling systems. Drawings should also include all IDF and MDF locations with a detailed layout of all racks, patch panels, trays, and wall fields.

2. Additional project information shall include Reline Details of all horizontal and backbone cable routes and pathways.

3. As-builts shall be submitted in electronic CAD format and in hardcopy at the end of the project.

1.5 Quality Assurance

A. Regulatory Requirements

1. All equipment shall be installed in a neat and professional manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the school district. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Substitutions

1. Conditions for consideration of “Or Equal” Products: Where products are specified by name and accompanied by the term “or equal”, the proposed “or equal” product will be considered when the following conditions are satisfied.

a. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements

b. Proposed product does not require extensive revisions to the Contract Documents.

c. With the exception of the product name or number and manufacturer’s name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.

d. Proposed product is fully documented and properly submitted.

e. Proposed product is compatible with and has been coordinated with other portions of the Work.

f. Proposed product provides specified warranty.

2. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

3. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.

4. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.

5. Submission is accompanied with proposed product’s Manufacturer signed written statement on Manufacturer’s letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 Warranty

A. Warranty: Installer must provide manufacturer’s warranty without cost to the owner during that time period, including materials, hourly costs, etc,.

B. Installer’s warranty shall guarantee workmanship for a period of one year, during which time any deficiency in installation shall be repaired or replaced at no additional cost to the school district. Contractor must respond within 2 business days of written notification.

PART 2 - PRODUCTS

2.1 Materials

A. Interior wet-applied adhesives, sealants, paints, and coatings: Comply with low-emitting requirements in Division 01 Section “Sustainable Design Requirements - LEED.”

B. Composite wood installed in building interior: Comply with California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM), Phase II for ultra-low-emitting formaldehyde (ULEF) resins or containing no added formaldehyde resins.

C. Distribution Racks and Cabinets

1. Floor Mounted Free Standing 2 Post Racks

a. Racks shall be UL Listed and of aluminum construction with a black polyurethane or mil finish. They shall be 84” tall with a 15” base depth. Rack base shall be pre-drilled for securing rack to the floor. Racks shall have 12/24 mounting screws included in the package.

b. Rack rails shall be spaced for 19” mounting rail-to-rail and shall be of a U shaped construction with 12/24 pre-tapped holes in the EIA-310-D standard hole pattern providing 45 rack spaces on both the front and rear. Rails shall have a universal side-drilling pattern to allow racks to be bolted together or attachment of accessories. Racks shall be secured to the floor with anchor bolts.

c. Vertical cable management channels shall be provided for each rack. Channels should allow for and facilitate orderly routing of distribution cables.

d. Acceptable racks: 6” Mighty Moe,

i. Or approved equivalent.

2. Floor Mounted Free Standing 4 Post Racks

a. Four post aluminum frame with EIA rails

b. 45 Rack Units

c. Black

d. Similar to Ortronics OR-MM67SVR

i. Or approved equivalent.

3. Floor Mounted Equipment Cabinet

a. The cabinet frame shall be constructed of four cold rolled steel components – top, bottom, left and right welded to form a self-supporting framework. The top and bottom shall be fabricated from 14ga cold rolled steel. The vertical uprights shall have integral cable management channels with provisions for hook and loop or traditional cable ties. The frame shall be bolted to the floor, and side by side to other frames.

b. The side covers shall be constructed of 19ga cold rolled steel with double bent flanges along the entire perimeter. The side covers shall lift off easily via grip handles assembled to the covers. The side cover shall have clusters of rectangular perforation to accommodate ventilation for equipment providing greater than 100 sq. in. of ventilation.

c. The front door shall be perforated and assembled to the frame via spring-loaded hinges at the top and bottom. The door shall be locking with a unique operator’s key. The operator’s key shall operate the front door only. The latch shall be

flush to the door. The window shall be a .125" acrylic panel secured to a reinforced steel frame.

d. The rear door shall be a steel door assembled to the frame via spring-loaded hinges at the top and bottom. The door shall be locking with a unique service personnel key. The service personnel key shall operate both the rear and front doors. The latch shall be push button operated. The rear door shall be reinforced and have a cluster of rectangular perforations for ventilation.

e. The top shall have a removable panel in the center, designed to be replaced with a cooling fan, and six 3" diameter cable entry knockouts; three along each side to route cables directly into vertical cable organizers minimizing the number of bends to the cables.

f. The bottom panel shall be similarly configured with 6 knockout locations. The cabinet bottom shall also be provided with holes for securing the cabinet to the floor.

g. The top cover shall accept the mounting of a 250 CFM cooling fan.

h. The cabinet shall be pre-configured for 19" mounting with universal hole spacing per EIA 310 D. The cabinet shall feature three sets of rails, front, center, and rear. The rear and center rails shall be the full internal height. The recess of all three sets of rails shall be adjustable forward and back. The rails shall be tapped for a #10-32 screw. The center rails shall be formed in a 'C' profile, 3" deep tapped on both the front and rear flanges so as to provide the functionality of an open frame rack. The front and rear rails shall be an L shape.

i. The entire enclosure shall be finished with a durable polyurethane powder coat – medium texture and shall be available in black.

4. All racks and cabinets shall be capable of supporting the weight and space of existing and proposed equipment. 30% growth capacity shall be provided in addition to detailed requirements.

5. Racks, cabinets and other termination equipment shall be properly secured to floor with appropriate anchors and bonded to Telecommunications Grounding System.

6. Unit shall be similar to

   a. Lowell L278-77,

   b. Or approved equivalent.

7. Provide (1) 8-port transient surge protection strip for each TR and per rack/cabinet in the TER and TRs.

D. Cable Management

1. Horizontal Cable Management

   a. Horizontal wire management panels are required for patch panels in certain racks. (See drawings for rack diagrams.)

   b. Horizontal cable management shall occupy 1 or 2 rack units, as shown on T Drawings.

   c. Similar to OR-MM6HMF1RU

      i. or approved equivalent

Vertical Cable Management

d. Vertical Cable management shall be provided for all racks. Provide 2 for each rack or cabinet.

e. Cable management shall be – Ortronics OR-60400510

i. Or approved equivalent.

E. Ladder-Type Aluminum Cable Tray (Ladder Rack)

1. All TR and TER locations shall receive ladder-rack style cable tray as shown in T-series drawings for cable distribution.

2. Class 5160 or Chatsworth "TELCO-Style Cable Runway," 12 and inch ladder rack from racks/cabinets from corridor or other wire routing space where indicated on drawings.

F. Basket Cable Tray:

1. Cablofil EZTray CF 54/300 EZ or approved equivalent.

2. 12" X 2" with associated mounting hardware.

3. 12" x 4" with associated mounting hardware.

4. 18" x 2" with associated mounting hardware.

5. Provide dual runs of cable tray as shown on T Drawings.

G. J-Hooks

1. J-Hooks shall be rated for low voltage cables

2. J-hooks shall be provided where cable tray and conduit are not present

3. J-hooks shall be installed on 5'-6' centers, not further apart.

H. Conduit

1. In-wall conduit shall be provided for work in new areas. Refer to T Drawings for conduit details.

2. Conduit bend radii shall follow current TIA/EIA standards for telecommunications.

3. Refer to T drawings for locations and sizes of all sleeves for telecommunications.

I. Gang Boxes

1. In-wall Gang Boxes for low voltage

a. Hubbell HBL985

b. Hubbell HBL986

J. Floor Boxes

1. In-floor box

a. Coordinate all floor boxes and poke-through devices for telecom equipment with electrical installer.

b. Floor box shall meet latest UL standards for scrub water resistance

c. Four-Compartment Combination Box similar to Wiremold RFB4

d. Six-Compartment Combination box similar to Wiremold EFB610.

e. Top of box shall allow for matching floor finish insert and be constructed of metal

f. Provide all brackets and accessories for proper telecommunications installation.

2. Poke through

a. Unit shall be similar to Wiremold Evolution Series with 5 gangs

K. Distribution Backboard

1. Plywood

a. ¾" AC-grade plywood shall be provided as shown on T drawing details to line the walls within the TR. The plywood should be provided in 4' x 8' sheets.

b. Plywood shall be void free and painted on all sides with two coats of fire-resistant paint.

L. Electrical Protection for Telecommunications

1. Telecommunications Main Grounding Busbar (TMGB) and Telecommunications Grounding Busbar (TGB)

a. Provide one TMGB in the Telecommunications Equipment Room as shown on T Drawings.

b. Provide a TGB in every Telecommunications Room and distribution cabinet location as shown on T Drawings.

c. The telecom grounding and bonding system shall be bonded to the main electrical ground for the facility.

M. Rack mounted power strip

1. Provide one 8 port transient, surge protection strip (UL Listed) for each rack or cabinet.

PART 3 - EXECUTION

3.1 Examination

A. Site Verification of Conditions

1. Contractor shall ensure that sufficient space has been allocated for the installation of all equipment per T Drawings prior to Installation. Clearances and existing equipment should be taken into consideration. If insufficient space exists, the Design consultant should be notified in writing, before proceeding with Installation.

3.2 Installation

A. Distribution Racks and Cabinets

1. Racks shall be assembled such that mounting rails are exactly perpendicular to the base.

2. Racks shall be secured to the floor using appropriate anchors.

3. Racks shall be grounded to the TGB or appropriate building ground using a minimum #6 grounding wire.

B. Distribution Backboard

1. Securely fasten backboard to wall-framing members to ensure it can support attached equipment.

2. Mount plywood on all available areas where telecommunications equipment may be located.

3. Refer to T Drawings for minimum coverage.

C. Ladder Rack and Cable Tray

1. Ladder rack and cable tray shall be properly secured using manufacturer recommended anchors and connectors.

2. Ladder rack and cable tray shall be routed according to T Drawing floor plans.

3. Ladder rack and cable tray shall be bonded to ground according to TIA/EIA 607.

D. Firestop

1. Provide re-enterable, non-hardening, intumescent putty, rated for floors or wall, UL approved assembly, with approved packing material for fire stopping inside building cable penetrations thru conduits sleeves.

2. The material used for sealing all openings shall have a fire rating equal to or greater than the floor ceiling, wall or partition material.

E. Sleeves and openings

1. The telecommunications contractor shall provide sleeves through all walls and floors to protect cabling and or raceways installed as part of the telecommunications system. All sleeves shall extend through the respective wall or partition and finish with a connector protective bushing.

2. Sleeves through all fire rated structures shall have appropriate fire stop system.

- END OF SECTION 27 05 00-

SECTION 27 10 00
STRUCTURED CABLING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Local Area Network (LAN) Cabling

B. Telephone Cabling

C. CATV Coaxial Cabling and Equipment

D. Termination Equipment for Telecommunications

E. Faceplates and Outlets

1.2 DEFINITIONS

A. “Backbone Cabling” refers to telecommunications cabling that provides interconnections between telecommunications rooms, equipment rooms, and entrance facilities.

B. “Communications Network Outlet (CNO)” refers to a collection of one or more mechanical cable termination device for horizontal cable in the work area.

C. “Drop” refers to the vertical transition to a location of one or more CNOs.

D. “Horizontal Cabling” refers to the cabling between and including the work area communications network outlet and the horizontal cross-connect in the telecommunications room.

E. “Jack” refers to a female-style telecommunication receptacle.

F. “Telecom Room (TR)” refers to an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the backbone or trunk cabling and horizontal cabling.

G. “Telecom Equipment Room (TER)” refers to a centralized space for telecommunications equipment that serves the occupants of the building, usually containing the headend equipment for the distribution systems found in the building.

1.3 REFERENCES

A. Industry Codes, Standards and Methods shall be observed, including the following:

1. ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA-568.1-D: Commercial Building Telecommunications Cabling Standard
3. ANSI/TIA-568-C.2: Balanced Twisted Pair Cabling and Components Standard
4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
5. ANSI/TIA-569-D: Telecommunications Pathways and Spaces
6. ANSI/TIA-570-C: Residential Telecommunications Cabling Standard
7. ANSI/TIA-606-B: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
8. ANSI/TIA-607-C: Commercial Building Grounding and Bonding Requirements for Telecommunications
9. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
10. ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
11. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition

12. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

B. Comply with all local, state and federal codes for telecommunications installations.

1.4 SYSTEM DESCRIPTION

A. Design Requirements

1. All systems and equipment must comply with the school district Technology and Architecture Standards, Latest Version.

2. LAN and Telephone Distribution:

a. Provide labor, materials, equipment, services and operations required for complete installation of LAN compatible with:

i. Ethernet 10Base-SX

ii. Ethernet 100Base-FX

iii. Ethernet 1000Base-SX

iv. Ethernet 1000Base-LX

v. Ethernet 10GBase-S

vi. Ethernet 10Base-LX4

vii. Ethernet 10GBase-L

viii. Ethernet 10GBase-LRM

ix. Fibre Channel 100-MX-SN-I

x. Fibre Channel 100-SM-LC-L

xi. Fibre Channel 200-MX-SN-I

xii. Fibre Channel 200-SM-LC-L

xiii. Fibre Channel 400-MX-SN-I

xiv. Fibre Channel 400-SM-LC-L

xv. Fibre Channel 1200-MX-SN-I

xvi. Fibre Chanel 1200-SM-LL-L

xvii. FDDI PMD ANSI X3.166

xviii. FDDI SMF-PMD ANSI X3.184

b. All wiring including copper and fiber optic employs a star topology.

i. Category 6 UTP wiring terminates on Category 6 RJ-45 jack at workstation and on Category 6 rack-mounted patch panel in telecommunications room. Connections wired per ANSI/TIA-568A.

ii. Multi-strand composite fiber optic cable connects distribution racks between telecommunications rooms and terminates on rack-mounted fiber optic patch panel.

c. Network cables routed from distribution racks throughout building as shown on T-Drawings. Drop to outlet installed in conduit and wall box, or dual-channel surface mounted raceway to communications outlet in classrooms, offices, or other locations indicated on T-Drawings.

i. Refer to notes on each drawing to determine exact installation methods.

ii. Note and record all cable lengths to the nearest foot.

iii. Replace any cable exceeding 90 meters (295 feet) and route to reduce length to a minimum of 90 meters. Complete all cable rerouting for compliance at no additional cost to School district.

iv. Identify to Design consultant prior to installation of any cables that cannot be reduced to 90 meters or less in total length (rise and run).

v. Strictly adhere to most current version of ANSI/TIA Telecommunications cabling standards.

vi. Unless otherwise noted on T-Drawings, provide ladder-type cable tray from corridor to distribution racks and termination fields in telecommunication rooms.

vii. Install “waterfall” device providing sweep from cable tray to data rack/cabinet and other vertical transitions.

d. Data and Telephone outlets: Category 6 rated RJ-45 type connectors with all four copper pairs terminated and tested in accordance with the 568B wiring standard.

e. Fiber Optic Horizontal and Backbone Cables: Terminate on panels in each rack and connectors with ceramic sleeves. Terminate and test all strands unless otherwise noted.

f. Permanently identify and label all cables and termination devices, at distribution rack and workstation in accordance with ANSI TIA 606 Standard or as agreed by Design consultant and school district.

g. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cable in place. All cable shall be terminated at both ends, unless noted in T-Drawings.

B. Performance Requirements

1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.

1.5 SUBMITTALS

A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.

B. Product Data: Submit manufacturer’s product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.

1. Communications outlets, faceplates, and accessories.

2. Fiber optic cable, patch cables and terminations.

3. Copper cable, patch cables and termination devices.

4. Inner duct and accessories.

5. Rack configurations and wiring diagrams.

6. Network cabling test equipment and process (routines).

7. Equipment Racks
8. Outlets

C. Samples:

1. Provide samples of outlets and assemblies as described below, prior to installation, for approval by designer.
2. Telecommunications outlets – Submit samples of telecommunications outlets to be provided including following components and characteristics:
   a. Flush mounted and Raceway outlets – Completely assembled faceplate and wall box with each type of outlet to be mounted in faceplate, including blank covers, dust covers, labeling field, cabling, and adapter plates and bezels required.
   b. Sample characteristics:
      i. Provide all components in colors selected by Design consultant.
      ii. Provide multiple outlet samples to accurately represent range of outlets to be provided.

D. Shop Drawings

1. The Contractor shall submit shop drawings of all systems showing major components of the systems. Submit wiring diagrams showing connections for all systems and equipment.

E. Quality Control Submittal

1. Test Reports: Submit complete sample test data and reports with exact labels used on cables, patch panels and faceplates.
2. Certificates
   a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
   b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in “Quality Assurance – Qualifications – Installer.”

F. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in “Operation and Maintenance Data” manual described in that Section.

1.6 QUALITY ASSURANCE

A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of school district is obtained.

B. Installer Qualifications: Qualified to cable, terminate and test data network cabling system specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 computer network installations of similar size, nature and complexity as specified for this project.

C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal”, the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied,

Design Consultant will return requests without action, except to record noncompliance with these requirements:

1. Proposed product does not require extensive revisions to the Contract Documents.
2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
3. Proposed product is fully documented and properly submitted.
4. Proposed product has received necessary approvals of authorities having jurisdiction.
5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
6. Proposed product provides specified warranty.
7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.7 WARRANTY

A. Installer’s Warranty: Provide manufacturer’s system warranty against electrical or mechanical defects for 1 year from date of final acceptance.

B. A fifteen (15) year Extended Product Warranty and Systems Assurance Warranty for this wiring system shall be provided by the Manufacturer as follows:

1. Extended Product Warranty: The Extended Product Warranty shall ensure against product and workmanship defects, that all approved cabling components exceed the specifications of ANSI/TIA 568B and Addenda for fiber link/channels and copper components, for a fifteen (15) year period. The warranty shall apply to all passive components, including both cable and connecting hardware as a combined system. Any claims cover replacement costs on any defective product, both material and labor. Extended warranties beyond fifteen (15) years will be considered.
2. System Assurance: The System Assurance shall cover the failure of the wiring system to support the application which it was designed to support as well as additional application(s) introduced in the future by recognized standards or user forums that use the ANSI/TIA 568B component and link/channel specifications for cabling, for a fifteen (15) year period.
3. System Certification: Upon successful completion of the installation and subsequent inspection, the School district shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable Manufacturers other than listed equipment

1. Hubbell
2. Amp
3. Tyco
4. TE Connectivity

B. All materials shall be new and unused except as noted in T-series Drawings.

C. All cables shall be plenum rated

D. System wiring and equipment installation shall be in accordance with good engineering practices as established by ANSI/TIA and the NEC. Wiring shall meet all state and local electrical codes. All wiring shall test free from all grounds and shorts.

E. Velcro straps shall be used for bundling wires. Wires shall be bundled loosely. Permanent cable ties are not acceptable.

F. Wiring system shall consist of the following:

1. Accessories and Appurtenances
2. Cable Management Devices
3. Fiber Optic Cable and Terminators (as indicated on drawings)
4. Copper and Fiber Patch cables
5. Remote Jacks
6. Termination/Patch Panels
7. Twisted Pair Data Cables
8. The Cable Infrastructure Project requires a structured cabling system, or equivalent single-manufacturer solution. The Category 6/6a portion of the cabling system shall comply with the link and channel performance requirements of ANSI/TIA 568-B.2-1 “Performance Specifications for 4-pair 100 Ohm Category 6 Cabling”. The cabling system shall be backed by a 15-Year System Warranty.
9. The work includes the provision for a complete and operable Local Area Network Building Data System consisting of active and non-active components. The cabling system and all wiring components shall meet and comprise an ANSI/TIA Category 6 Wiring System. With master and remote data equipment the completed system shall provide 1Gbs Fiber Optic Fast Ethernet communications backbone support to the edge switches and Ethernet 1000 BASE-T to the workstation data jacks. The system shall provide such services as computer networking, data transmission, graphics and other multi-media offerings.
10. Provide one home run cable from each data/voice jack to appropriate wiring closet.
11. Cable length of home run cable shall not exceed 90 meters.
12. All Modular jack panels shall be wired to ANSI//TIA 568B

2.2 J-HOOKS

A. Cooper B-Line BCM-21, 23 or 64.

1. Provide in sufficient quantity for 15% future expansion.
2. Installed no more than 6’ apart.
3. Install in any areas without cable tray above false ceilings.

2.3 HORIZONTAL CABLES

A. Category 6 UTP Voice, Data and Security cables shall each have a distinctive color. Submit for approval from design team.

1. Hubbell C6SPxx
2. Hubbell C6RPxx
3. Hitachi 30025-8
4. Hitachi 30024-8

B. Category 6a UTP Wireless cables shall each have a distinctive color. Submit for approval from design team.

1. Hubbell
2. Hitachi

C. RG-11 Quad Shield Coaxial Cable

1. Commscope RG-11 Quad Shield Coaxial Cable
2. Or approved equal.

D. RG-6 Quad Shield Coaxial Cable

1. Commscope RG-6 Quad Shield coaxial cable.
2. Or approved equal.

2.4 BACKBONE CABLES

A. Multi-pair Cat 5 Riser Cables

1. Hitachi 30093-50
2. Hitachi 30172-100

B. Single Mode Fiber Optic Cables

1. 6 Strand
2. Armored or installed within inner duct
3. Hitachi 61579-12

C. Multi-Mode Fiber Optic Cables

1. 24 Strand
2. 50 Micron, OM4.
3. Hubbell HFC1012P4
4. Hitachi 61868-12

2.5 TERMINATION FIELDS

A. Category 6 48-Port Patch Panels.

1. Patch Panels shall be modular
2. Provide 15% spare capacity
3. Hubbell Modular Cat 6 UTP 48 Port Patch Panel
4. Hubbell PCBLMGT Rear Cable Manager

B. Category 6a 48-Port Patch Panels.

1. Provide 15% spare capacity
2. Hubbell
3. Hubbell Rear Cable Manager

C. Fiber Enclosure
1. Hubbell 2U FCR350SP36R
2. Hubbell 2U FCR350SP54R
3. Hubbell 3U FCR525SPR
4. Hubbell 4U FCR700SP

D. Fiber Adaptor Panels
1. Hubbell FSPLCDM6AQ
2. Hubbell FSPLCQM6AQ
3. Hubbell FSPLCDS6
4. Hubbell FSPLCQS3

E. Fiber Connector
1. Hubbell FCLC900K50GM12 50/125um OM4 Aqua

F. 110 Blocks
1. Hubbell 110BLK50FTK5
2. Hubbell 110BLK100FTK5
3. Hubbell 110BLK300FTK5

2.6 OUTLETS

A. Category 6/6a Voice and Data Jacks
1. Hubbell

B. Faceplates
1. Hubbell

C. Frames
1. Angled frames shall be used where required due to cable bend radius and box depth.
2. Hubbell

D. Coaxial Connectors
1. Crimp termination F-connectors shall be used.
2. Hubbell

2.7 PATCH CORDS

A. Cat 6/6A Copper Patch Cords
1. Hubbell

B. SM/MM Fiber Patch Cords
1. Hitachi OS2, Yellow

C. Coaxial Patch Cords
1. Leviton RG-6 coaxial patching cords

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which telecommunications cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.

1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

A. Protection: Provide adequate protection of equipment and hardware before and after installation.

B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.

1. Identify any additional telecommunications outlets, circuits, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
2. Contact local telephone, network and CATV company to identify all circuits providing existing services.
3. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

A. Provide and install all components necessary to install complete telecommunications cabling and equipment systems, including (but is not limited to) connectors, patch cables, terminators, etc…

1. Cable runs shall be continuous and unbroken from end to end. Splicing of any Telephone, LAN, or coaxial video distribution cable is prohibited. Horizontal cabling for LAN and telephone shall end in rack-mounted patch panels.
2. Secure all horizontal cables within ceiling cavities to building structure.
3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.

5. Verify all horizontal cable run lengths prior to installation. Re-distribute horizontal cabling to maintain distance requirements and maintain pathway route accessibility.
6. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.
7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
8. Provide a 10-foot service loop in all fiber optical cables to permit future cable splice and repair at all building entrance points and termination points.
9. Place cables in compliance with ANSI/TIA-568.B standards and BICSI recommended methods.
10. Tight 90-degree bends are unacceptable, and use of plastic “cinch-type” tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable’s electrical or optical characteristics.
11. Cable bundles shall be neatly routed with a service loop to provide 10 feet of slack at the cross-connect end and as noted in the T-drawings. Cable bundles shall be secured using only black Velcro cable wraps.
12. 10 feet of service loop shall be provided in the ceiling at each workstation. Contractor shall not secure service loop in coils, but route in such a manner as to minimize EMI.
13. Wireless outlet locations
    a. Wireless locations shown on T-series drawings shall be installed outside of a faceplate.
    b. Ceiling shall be marked and as-builts shall reflect the location of all terminated ends and service loops as directed by SCHOOL DISTRICT personnel.
    c. Cable shall be terminated in a female RJ-45 female jack, and left with a service loop as described in T-series drawings. Cable shall be tested and documented per previous requirements.
    d. After completion of wireless site survey, outlet shall be re-terminated for connection to Wireless Access Point.

B. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using TIA/EIA-569A “Cabling Pathway Standard” for UTP cable separations from sources of EMI:

1. Minimum separation distance from Power Source at 480 V or less:

CONDITION	< 2kVA	2-5 kV	> 5 kVA
a. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	6 in.	12 in.	24 in.
b. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	3 in.	6 in.	12 in.
c. Power lines enclosed in a grounded metal conduit (or equivalent shielding)	3 in.	6 in.	12 in.

in proximity to grounded metal conduit pathway			
d. Transformers & Elec. Motors	40 in.	40 in.	40 in.
e. Fluorescent Lighting	12 in.	12 in.	12 in.

C. Interior Fiber Optical Cable Installation Requirements

1. Install all interior fiber optic backbone cables in 1-inch plenum-rated inner duct, similar to Pyramid Industries #PLM100(T) where fiber optical cable placed in cable tray or otherwise fully supported in accordance with manufacturer's requirements.
2. Install all outdoor rated communications cables not rated for plenum placement in interior environments in metallic conduit, according to NEC Articles 770 and 800.
3. Install inner duct for fiber optic cabling in all conduits, as necessary for proper support of cables, or where required to assure pull-in tension not exceeding manufacturer's recommendations.
4. Provide pull strings or ropes in all conduit and inner duct used for communications cables.

D. Cabling System

1. Where not provided as part of the electrical work or the data/voice work, the Contractor shall furnish and install necessary conduit, raceways, pull boxes, outlet boxes and cable to provide a complete system as herein specified. All wiring shall be tested for continuity and freedom of all grounds and short-circuits. All outlet boxes shall be as specified for other wiring devices; size as required by equipment manufacturer.
2. Cables shall be installed in raceways or EMT, as detailed on the drawings and/or as specified, above non-accessible ceilings, where exposed, and wherever it may be subject to physical damage. Where not provided as part of the electrical work or the data/voice work, the Contractor shall provide a raceway (conduit) from each outlet to above the accessible ceiling. Otherwise, cable shall be installed above accessible suspended tile ceilings and attached to building structure with approved bridle rings or J-hooks, cable is not permitted to rest on ceiling. The cable routes used shall avoid steam lines, power wiring and other utilities that may adversely affect the system's performance or result in damage to the cable. If the routes required place the cable in proximity to these utilities, the cable shall be suitably protected. Under no circumstances shall cable be run in hangers used for pipes or electric conduits nor shall the cable be supported in any way by attachment to these pipes, conduits or ceiling hangers.
3. During the installation work, improper bending, stretching, twisting, kinking, pinching or any other improper handling must not deform the cable. All cable runs shall contain "S" loops or other means to accommodate expansion and contraction. Coaxial cables shall not bend at any point of installation to a radius of less than ten times the diameter of the cable or less than the value recommended by the cable manufacturer. Cable connected to electronic equipment in the system shall be tagged to show its function and the location of its other end. All labels shall be of durable material and securely fastened to the cable.
4. All cables shall be fastened securely with suitable hardware so as to avoid sharp bends and to prevent rubbing against sharp corners and in a manner to prevent injury or physical distortion.
5. Wiring for all wall-mounted equipment shall be concealed in raceway (conduit) from outlet to above removable ceilings, unless noted otherwise.
6. Wiring installed above removable ceilings shall be installed on bridle rings. No cables shall be installed on roof or exterior of building.

7. Infrastructure properly terminated on backboard, neatly arranged in orderly fashion and accurately identified.

8. Equipment cabinet(s) anchored to wall or floor utilizing an approved method.

9. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.

E. Install all cable in accordance with National, state and local codes and ANSI/TIA Standards, and BICSI methods.

1. Follow manufacturer's guidelines and requirements for all cable termination.

2. Install and connect #6 AWG to bond all equipment racks, conduits and cable trays to busbar in each telecom room. Each telecom room shall be interconnected to TER with #3 AWG bonding backbone to TMGB per Telecommunications Grounding Diagram. It shall be left to licensed electrician to interconnect TMGB with lowest point of building ground. Contractor shall verify TMGB has been bonded to building ground before declaring completion.

F. Permanently identify all system components following ANSI/TIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:

1. Identification: Provide permanent identification labels for outlets, faceplates, patch panels, access panels and entrance facilities.

2. Each individual cable shall be labeled on both ends of cable terminations regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate school district personnel for appropriate labeling scheme. The intended format and labeling material must be approved by school district Technology Department before labeling begins.

3.4 TESTING

A. LAN and Telephone

1. Upon completion of work, all parts of the telecommunications installation shall be tested by the Telecommunications Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.

2. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.

B. As-Builts

1. Accurate as-built drawings shall be provided in electronic and hard copy format.

a. Drawings shall accurately show and describe all cable routing and equipment location in redline format.

b. 3 copies of electronic (CAD) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to the school district.

c. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.5 ACCEPTANCE

A. Contractors work shall be considered complete after the following conditions have been met:

1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
2. A school district Technology representative has successfully tested the “LIVE” system.
3. All punch list items have been reconciled.
4. All disturbed ceiling panels, firestopping materials, covers, etc. have been properly reinstalled.
5. A 1-Year Installers warranty has been given to a school district Technology representative.
6. Submit Manufacturers Extended Warranty Application.

-END OF SECTION 27 10 00-

SECTION 27 41 00
AUDIO VISUAL AND SOUND SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Classroom Audio Visual Cabling Harness. (By Owner)
2. Classroom / Conference Room Electronic Displays (By Owner)
3. Gymnasium A/V System
4. Cafeteria Sound System
5. Music Room Sound System
6. Digital Signage Equipment
7. Seclusion Room Equipment

1.2 DEFINITIONS

A. “Sound Enhancement” refers to a stand-alone sound system which includes speakers, speaker wire, an infrared microphone and receiver, a pendant style microphone and amp/mixer unit.

B. “Communications Network Outlet (CNO)” refers to a collection of one or more mechanical cable termination device for horizontal cable in the work area.

C. “Drop” refers to the vertical transition to a location of one or more CNOs.

D. “Horizontal Cabling” refers to the cabling between and including the work area communications network outlet and the horizontal cross-connect in the telecommunications room.

E. “Jack” refers to a female-style telecommunication receptacle.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

1. A/V Systems

a. A Classroom A/V harness shall be provided and include A/V cabling, faceplates, connectors and electronic displays.

b. A Gymnasium A/V system shall be provided and include A/V cabling, faceplates, connectors, controllers, mixers, DSPs, amplifiers, loudspeakers, and electronic displays.

c. A Cafeteria audio system shall be provided and include cabling, faceplates, connectors, controllers, electronics and associated components.

d. A Music Room audio system shall be provided and include cabling, faceplates, connectors, controllers, electronics and associated components.

2. All stand-alone sound systems must have call override from the Intercom/PA system in the case of an emergency.

B. Performance Requirements

1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.

2. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:

   a. ANSI/TIA-568-C.0: Generic Telecommunications Cabling for Customer Premises

   b. ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standard

   c. ANSI/TIA-568-C.2: Balanced Twisted Pair Cabling and Components Standard

   d. ANSI/TIA-568-C.3: Optical Fiber Cabling Components Standard

   e. ANSI/TIA-569-B: Commercial Building Standard for Telecommunications Pathways and Spaces

   f. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard

   g. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings

   h. ANSI-J-STD-607-A: Commercial Building Grounding and Bonding Requirements for Telecommunications

   i. ANSI/TIA-758-A: Customer-Owned Outside Plant Telecommunications Cabling Standard

   j. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition

   k. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.

B. All systems and equipment must comply with the school district Technology and Architecture Standards, Latest Version.

C. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.

   1. Sound coverage and pressure level diagram for each auxiliary sound system

   2. Sound Amplifier

   3. Sound Speakers

   4. Sound Microphones

   5. Sound Cabling and Wiring

   6. Audio Visual cables and connectors

   7. Audio Visual Mixers

   8. Controllers

   9. Amplifiers

   10. Electronic Displays

   11. Communications outlets, faceplates, and accessories.

   12. Wall outlets

D. Samples: Provide samples of equipment, cables, microphones and assemblies as described below, prior to installation, for approval by designer.

1. Sound Enhancement – Submit samples of audio visual cables provided including following components and characteristics:

a. Sample characteristics:

i. Provide all components in colors selected by Design consultant.

ii. Provide multiple samples where required to accurately represent range of cables to be provided.

E. Shop Drawings

1. The Contractor shall submit shop drawings of all systems showing major components of the systems. Submit wiring diagrams showing connections for all systems and equipment.

F. Quality Control Submittal

1. Test Reports: Submit complete sample test data and reports with exact labels used on cables and faceplates.

2. Certificates

a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.

b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in “Quality Assurance – Qualifications – Installer.”

G. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in “Operation and Maintenance Data” manual described in that Section.

1.5 QUALITY ASSURANCE

A. All Work shall be installed in a first class, neat and professional manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of the school is obtained.

B. Installer Qualifications: Qualified to cable, terminate and test cabling system specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.

C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal”, the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:

1. Proposed product does not require extensive revisions to the Contract Documents.

2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.

3. Proposed product is fully documented and properly submitted.

4. Proposed product has received necessary approvals of authorities having jurisdiction.

5. Proposed product is compatible with AND has been coordinated with other portions of the Work.

6. Proposed product provides specified warranty.

7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.

9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.

10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 1 year from date of final acceptance.

1. System Certification: Upon successful completion of the installation and subsequent inspection, the Authority shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 - PRODUCTS

2.1 MATERIALS – ALL MATERIALS SHALL BE NEW AND UNUSED

A. Acceptable Products

1. Classroom A/V cabling (by Owner)

a. Rapid Run / C2G

b. Or approved equal

2. The Auxiliary Sound and A/V Systems are based on Extron, Shure, Middle Atlantic, Epson and other like reputable manufacturers.

a. Equipment substitutions must be submitted in writing to the design team for review and approval.

b. Any equipment not meeting the design criteria will be rejected at the contractor's expense.

B. J-Hooks

1. Cooper B-Line BCM-21, 23 or 64.

a. Provide in sufficient quantity for 15% future expansion.

b. Installed no more than 6' apart.

c. Install in any areas without cable tray above false ceilings.

2. Wall Mounted Interactive Panel

a. Promethean ActivPanel 75”

3. Wall Mounted LED

a. LG V652-AVT2

C. Classroom A/V Harness (by Owner)

1. The instructor’s station “L” and “M” assembly shall include the following cables. (see T series drawings for exact cable types and connections)

a. Audio

i. LG LASC27 Sound Bar

ii. 3.5 MM Stereo terminated connectors

b. HDMI & USB

i. C2G Optical HDMI

ii. C2G USB 2.0 High Speed Transmitter and Receiver Set over Cat 6 UTP

D. Gymnasium A/V System

1. Equipment Cabinet

a. Middle Atlantic 26 RU wall-mounted equipment cabinet with perforated locking front door.

2. Amplifier

a. QSC CMX500VA

b. Crown CDI 1000

3. Feedback Suppressor

a. Behringer FBQ1000

4. Mic Splitter

a. Behringer DS2800

5. A/V Plates

a. Custom XLR Mic/Line plates

b. Custom HDMI / 3.5 mm / VGA

6. AV Cabling

a. Extron Pro (length varies)

7. Mixer

a. Rolls RM82

8. Speakers

a. Community R.5-99TZ

9. Wireless Mic System

a. Shure SLX 124/85/SM58 Combo

10. Assistive Listening
    a. Listen Technologies LS-54-072
11. CD Player
    a. Tascam CD-200BT
12. Projector Mount
    a. Wall mount
13. Projector Bracket
    a. Universal Mount
14. Projector
    a. Epson Pro G7400u with lens or similar for rear projection
15. Shunt Relay
    a. Atlas AA-PPRC
16. Power Sequencer
    a. Furman M-8DX
17. Rear Projection Screen
    a. See Division 11
18. Wired Microphone
    a. Shure SM58S (Provide 3)
19. Microphone Stands
    a. Atlas TEB-E (Provide 3)
20. Wiring
    a. Multi-conductor control cable.
    b. 18/2 AWG Speaker Wiring
    c. 14/2 AWG Speaker Wiring
    d. 3.5 mm audio
21. Miscellaneous Connectors
    a. Provide Neutrik NC3 series “XLR”, Neutrik NP3C “TRS” or Canare F-09 “RCA” connectors.
    b. Provide Switchcraft N112B connectors.

E. Cafeteria Equipment: (substitutions must provide equal or greater performance)
1. Equipment Cabinet
    a. Middle Atlantic DWR 24 RU swing open wall cabinet with perforated locking door.
2. Amplifier

a. QSC CMX300VA

3. Feedback Suppressor

   a. Behringer FBQ1000

4. Mic Splitter

   a. Behringer DS2800

5. A/V Plates

   a. Custom XLR Mic/Line plates

6. Mixer

   a. Rolls RM82

7. Wireless Mic System

   a. Shure PGxD

8. Assistive Listening

   a. Listen Technologies LS-54-072

9. CD Player

   a. Tascam CD-200BT

10. Shunt Relay

    a. Atlas AA-PPRC

11. Power Sequencer

    a. Furman M-8DX

12. Mic Level Input

    a. Neutrik Combo ¼” XLR

13. Line Level Input

    a. RDL D-CIJ3.

14. Wired Microphone

    a. Shure SM58S (Provide 3)

15. Microphone Stands

    a. Atlas TEB-E (Provide 3)

16. Loudspeakers

    a. Extron SI 26CT

17. Wiring

    a. Multi-conductor control cable.

    b. 18/2 AWG Speaker Wiring

    c. 14/2 AWG Speaker Wiring

d. 3.5 mm audio

18. Miscellaneous Connectors

a. Provide Neutrik NC3 series “XLR”, Neutrik NP3C “TRS” or Canare F-09 “RCA” connectors.

b. Provide Switchcraft N112B connectors.

F. Music Room Equipment: (substitutions must provide equal or greater performance)

1. Equipment Cabinet

a. Middle Atlantic DWR 24 RU swing open wall cabinet with perforated locking door.

2. Amplifier

a. QSC GX3

3. Feedback Suppressor

a. Behringer FBQ1000

4. Mic Splitter

a. Behringer DS2800

5. A/V Plates

a. Custom XLR Mic/Line plates

6. Mixer

a. Rolls RM82

7. Wireless Mic System

a. Shure PGxD

8. Assistive Listening

a. Listen Technologies LS-54-072

9. CD Player

a. Tascam CD-200BT

10. Shunt Relay

a. Atlas AA-PPRC

11. Power Sequencer

a. Furman M-8DX

12. Mic Level Input

a. Neutrik Combo ¼” XLR

13. Wired Microphone

a. Shure SM58S (Provide 3)

14. Microphone Stands

a. Atlas TEB-E (Provide 3)

15. Loudspeakers

a. EV Evid 6.2

16. Wiring

a. Multi-conductor control cable.

b. 18/2 AWG Speaker Wiring

c. 14/2 AWG Speaker Wiring

d. 3.5 mm audio

17. Miscellaneous Connectors

a. Provide Neutrik NC3 series “XLR”, Neutrik NP3C “TRS” or Canare F-09 “RCA” connectors.

b. Provide Switchcraft N112B connectors.

G. Digital Signage Equipment

1. Digital Signage Software

a. Triple Play

2. Digital Signage Computer

a. Mac Mini 2.8 GHz

3. Encoders

a. Media Master MM-1281-HD Encoder

4. Decoder

a. Media Master MM-1276 Decoder

5. Blu Ray Player

a. Samsung

6. Accessories

a. Patching cords for connection type

7. 47” Signage Display

a. LG 47ly54OS

8. 75” Signage Display

a. LG 75TC3D

H. Seclusion Room Equipment

1. LED Monitor

a. Totevision LED-1003HDLX

2. Camera

a. Marshall CV350

b. With ceiling mounts

3. Wiring

a. HDMI Cable

b. Power Conductors

4. Ceiling Enclosure

a. FSR CB-12 with receptacle

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which AV cabling and sound enhancement equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.

1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.

2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.

3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.

4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.

5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

A. Protection: Provide adequate protection of equipment and hardware before and after installation.

B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.

1. Identify any additional outlets, circuits, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.

2. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

A. Provide and install all components necessary to install complete AV cabling and sound enhancement equipment systems, including (but is not limited to) connectors, electronics, terminators, pass-thrus, cables etc…

1. Cable runs shall be factory terminated. Splicing of any cable is prohibited

2. Secure all cables within ceiling cavities to building structure.

3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.

4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.

5. Verify all horizontal cable run lengths prior to installation. Ensure cables do not exceed distances that would degrade the signal transmission requirements

6. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.

7. Install cables in EMT in all unfinished or exposed areas

8. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.

9. Place cables in compliance with ANSI/TIA/standards and BICSI recommended methods.

10. Tight 90-degree bends are unacceptable, and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.

11. Communications outlets shall be located to be no more than 6 feet from an electrical outlet.

B. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using TIA/EIA-569A "Cabling Pathway Standard" for UTP cable separations from sources of EMI:

1. Minimum separation distance from Power Source at 480 V or less:

CONDITION	< 2kVA	2-5 Kva	> 5 kVA
a. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	6 in.	12 in.	24 in.
b. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	3 in.	6 in.	12 in.
c. Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to grounded metal conduit pathway	3 in.	6 in.	12 in.
d. Transformers & Elec. Motors	40 in.	40 in.	40 in.
e. Fluorescent Lighting	12 in.	12 in.	12 in.

C. Install all cable in accordance with National, state and local codes and TIA/EIA Standards, and BICSI methods.

1. Follow manufacturer's guidelines and requirements for all cable termination.

D. Permanently identify all system components following TIA/EIA-606A “Administration Standard for Commercial Telecommunications Infrastructure” with identification format:

1. Identification: Provide permanent identification labels for outlets, faceplates and cables.

2. Each individual cable shall be labeled on both ends of cable terminations regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate school personnel for appropriate labeling scheme. The intended format and labeling material must be approved by the school Technology Department before labeling begins.

3.4 TESTING

A. A/V and Sound Systems

1. The contractor shall test all aspects of the Audio/Visual Systems once it is installed and demonstrate these functions to the owner of owner’s representative.

a. Speaker levels shall be verified to function individually and as a unit.

b. Video Displays shall be verified to display from all input sources.

c. Control of the system shall be shown to control all aspects of the systems.

d. Levels shall be set for all outputs.

e. EDID and HDCP compliance shall be setup and verified.

f. Microphones shall be demonstrated to work as intended by the manufacturer.

B. Audio Visual Cables

1. The contractor shall test all cables included in the harness for proper signal transmission based on manufacturer standards.

2. The contractor shall record remove any cable that does not meet manufacturer standards and replace it with a correctly functioning cable.

3. The contractor shall demonstrate that the installed cables meet manufacturer standards for signal transmission prior to the job being considered complete.

C. Sound Enhancement System

1. The contractor shall test all aspects of the sound enhancement amp/mixer once it is installed and demonstrate these functions to the owner of owner’s representative.

a. Speaker levels shall be verified to function individually and as a unit

b. Microphones shall be demonstrated to work as intended by the manufacturer.

3.5 AS-BUILTS

A. As-builts shall be provided by the contractor in hardcopy and electronic CAD format prior to completion.

B. As-builts by contractor must include parts lists and wiring diagrams that clearly indicate all equipment, locations, wiring and connections.

C. Owner’s manuals shall be supplied as part of the as-built documentation.

3.6 DEMONSTRATION AND TRAINING

A. All aspects of the systems must be demonstrated for the owner at the time of training

B. A minimum of 16 hours of training shall be provided.

C. Training shall be video and audio recorder for the owner and turned over to the owner at acceptance.

3.7 ACCEPTANCE

A. Contractors work shall be considered complete after the following conditions have been met:

1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.

2. Equipment installation is complete and all functions have been tested and documented to function as designed and per the manufacturer's recommendations.

3. All punch list items have been reconciled.

4. All disturbed ceiling panels, fire stopping materials, covers, etc. have been properly reinstalled.

5. A 1-Year Installers warranty has been given to a school Technology representative.

6. Submit Manufacturers Extended Warranty Application.

-END OF SECTION 27 41 00-

SECTION 27 50 00
PA AND CLOCK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes
1. This section includes Integrated Intercom/PA/Master Clock Systems. It includes requirements for Integrated Electronic Communications Network systems components including:
   a. Administrative telephones
   b. Ceiling and Wall mounted speakers
   c. Public Address and Intercom Systems
   d. Digital Readouts
   e. Power Supplies
   f. Wiring
   g. Paging Horns
   h. Master Clock
   i. Program Sources

1.2 SYSTEM DESCRIPTION

A. Design Requirements
1. The facility intercommunication system shall be a low voltage system that utilizes a copper cable infrastructure to distribute a user-defined input in a single or bi-directional manner. The system shall be capable of multiple, simultaneous conversations on separate channels throughout the facility through telephones and loudspeaker assemblies. A programmable master clock with correction of secondary clocks shall also be included as part of the overall system. The system shall be microprocessor based and be fully compatible with the telephone system installed within the facility. In addition, the system must be expandable to meet the user's future expansion needs and be programmable from a computer terminal located at the facility.

B. Performance Requirements
1. Capability to fully interconnect with the facility telephone system.
2. Rack/Cabinet mountable equipment
3. Announcement distribution from a central location to zones, individual classrooms, groups or all facility speakers
4. Broadcast of user defined input (radio signal, compact disc, aux input, etc.) to zones, individual rooms, groups or all facility loudspeakers
5. Emergency cut-in to all speakers in an emergency situation from a central location
6. Two-way intercommunication between the central rack, any call-in location or any selected two-way speaker location
7. Hands free communications by means of a loudspeaker or speakerphone used as a transducer or speaker/microphone combination
8. Visual and audio monitoring of all intercommunication system activity
9. Volume and level controls for all centrally located intercommunication system equipment
10. Adjustment and correction of building-wide clocks relative to a centrally located master clock
11. Tone distribution based off the master clock that can be partitioned into zones
12. Capability to tie into any auxiliary sound system throughout the facility
13. High priority call-in from any telephone in an emergency situation

1.3 SUBMITTALS

A. Product Data
1. Submit equipment prints, panel diagrams, full electronic wiring diagrams and specifications sheets for items included herein. Provide a tabulation of the specification

clearly comparing the submitted items with the items specified. Specifications shall be submitted for all items

B. Shop Drawings
   1. Shop drawings detailing integrated electronic communications network systems including the built-in station arrangement and equipment cabinet arrangement.
   2. Wiring diagrams detailing power, signal and control.
   3. Typical connections for all types of equipment.
   4. A riser diagram for the system showing all connections, interconnections and all provisions available for future expandability.

C. Samples
   1. Provide a sample of all equipment and components that will be installed in a typical classroom.

D. Quality Assurance/Controls Submittals
   1. Test Reports
      a. Calculations, charts and test data for the system demonstrating full functionality
   2. Certificates
      a. A certificate of completion of installation and service training.
   3. Manufacturer's Instructions
      a. User's Manual shall be provided and adhered to in all circumstances unless approved by the authority.

1.4 QUALITY ASSURANCE

A. Qualifications
   1. All items of equipment including wiring and cable shall be designed by the manufacturer to function as a complete system and shall be accompanied by the manufacturer's complete service notes and drawings detailing all interconnections
   2. The contractor shall be an established communications and electronics contractor that has had and currently maintains a locally run and operated business for a minimum of five years. The contractor shall utilize an authorized distributor of the equipment supplied for this project location with full manufacturer's warranty privileges.
   3. The contractor shall show satisfactory evidence that the supplier maintains a fully equipped service organization capable of furnishing adequate inspection and service to the system. The supplier shall maintain at his facility the necessary spare parts to properly service the equipment.

B. Regulatory Requirements
   1. Electrical Component Standard: Provide work complying with the applicable requirements of NFPA 70 "NEC" including, but not limited to:
      a. Article 250, Grounding
      b. Article 300, Wiring Method
      c. Article 310, Conductors for General Wiring
      d. Article 725, Remote Control, Signaling Circuits
      e. Article 800, Communications Systems
   2. NFPA 75 – Standard for Protection of Electronic Computer Data Processing Equipment
   3. NFPA 77 – Recommended Practice on Static Electricity
   4. NFPA 101 – Life Safety Code
   5. NFPA 1600 Disaster Management, Chapter 5.9 Communications and Warning.
   6. BICSI TDMM
   7. ANSI/EIA/TIA Compliance: Comply with the following Electronics Industry Association Standards:
      a. Sound Systems, EIA-160
      b. Loudspeakers, Dynamic Magnetic Structures and Impedance, EIA-299-A
      c. Racks, Panels and Associated Equipment, EIA-310-A
      d. Amplifiers for Sound Equipment, SE 101-A
      e. Speakers for Sound Equipment, SE 103
      f. 568-B Commercial Building Telecommunications Wiring Standards

g. 569 – Commercial Building Standard for Telecommunications Pathways and Spaces.
h. 606 – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
i. 607 – Commercial Building Grounding and Bonding Requirements for Telecommunications.

C. Certifications
1. The installing contractor must be a certified by the manufacturer on the equipment being installed.
2. Installation and start up of all systems shall be under the direct supervision of a local agency regularly engaged in installation, repair, and maintenance of such systems. The supplier shall be accredited by the proposed equipment manufacturers and be prepared to offer a service contract for system maintenance on completion of the guarantee period and provide the names, locations, and size of five (5) recent successful installations in the area
3. The agency providing equipment shall be responsible for providing all specified equipment and mentioned services for all equipment as specified herein. The agency must be a local authorized distributor of all specified equipment for single source of responsibility and shall provide documents proving such. The agency must provide written proof that the agency is adequately staffed with factory-trained technicians for all of the specified equipment. The agency must have established business for and currently be providing all services for the equipment to be provided for a minimum of 15 years.

D. Pre-Installation Meetings
1. The Contractor shall visit the sites and familiarize himself with the existing conditions and field requirements prior to submitting a proposal.

1.5 QUALITY ASSURANCE

A. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:
1. Proposed product does not require extensive revisions to the Contract Documents.
2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
3. Proposed product t is fully documented and properly submitted.
4. Proposed product has received necessary approvals of authorities having jurisdiction.
5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
6. Proposed product provides specified warranty.
7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

B. Mockups: provide a working example of the system for the owner to review prior to system-wide purchase and installation

1.6 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading
   1. Deliver products in factory containers to the site.
   2. Handle carefully to avoid damage.

B. Storage and Protection
   1. Store in clean, dry space in original containers. Protect products from fumes and construction traffic.

1.7 WARRANTY

A. Special Warranty
   1. On-the-premise maintenance shall be provided at no cost to the purchaser for a period of two (1) year (parts and labor) from date of acceptance unless damage or failure is caused by misuse, abuse, neglect, or accident. The warranty period shall begin on the date of acceptance by the authority/design consultant.
   2. Products and systems are covered by a five (5) year (parts only) limited warranty from the date of acceptance. The warranty period shall begin on the date of acceptance by the authority/design consultant.

1.8 COMMISSIONING

A. In-Service Training
   1. The contractor shall provide a minimum of eight hours of in-service training with this system. These sessions shall be broken into segments that will facilitate the training of individuals in the operation of this system at the site. Operators Manuals and Users Guides shall be provided at the time of this training.
   2. All passwords and codes necessary to operate and maintain the system must be given to the owner prior to commissioning of the system.
   3. The installer shall provide a minimum of 2 electronic and 2 hardcopies of the operation and maintenance manuals during commissioning.

1.9 MAINTENANCE

A. Extra Materials
   1. The contractor shall guarantee availability of all specified equipment from an authorized distributor of all equipment specified under this section.

B. Maintenance Service
   1. The contractor shall guarantee availability of local service by factory-trained personnel.
   2. The contractor shall, at the authority's request, make available a service contract offering continuing factory authorized service of the system after the initial warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Vendors
   1. Intercom and Master Clock shall be from the same manufacturer, or shown to be fully compatible, and be designed to function as a unit.
   2. Catalog and part numbers must be from the most current vendor catalogs available at the time of design and installation.
   3. Basis of Design:
      a. Intercom/PA - Telecor
      b. Clocks - Telecor
      c. Owner (FCPS) shall provide headend electronics and equipment. Supplied equipment as part of this contract shall fully function with the owner's headend equipment.
   4. Equals must be submitted to the designer and owner for review prior to approval or rejection.

2.2 MATERIALS

A. Supply and install a complete Public Address, Intercom and Master Clock infrastructure system. The system shall provide and install a Telecor XL/II system that connects to the installed cabling and devices.
   1. Administrative Handsets
      a. The intercom/paging system control console shall be microcomputer based, desk top console, occupying no more than 75 sq. inches of desk space and weighing 2 lbs. It shall be manufactured of high impact, molded plastic with a standard 12 button keypad. It shall be Model MCC-300.
      b. The console shall provide selected, two-way voice communications and signaling between the console and room stations as well as between other control consoles in the system. The console shall be equipped with a telephone handset with a retractable cord to allow private conversations. A built-in microphone and speaker shall provide for push-to-talk intercom conversations.
      c. Incoming calls shall be annunciated on a two line 20-character LCD backlit digital display by room number and priority level. The display shall be angle adjustable to ensure the clearest viewing of console information.
      d. All incoming calls shall be held in memory and displayed sorted by priority and order received. Each of the six levels of priority shall be displayed by a unique priority prefix and call-in tone. The console shall also have facilities for reviewing all incoming calls stored in memory
      e. The distribution of program material shall be controlled from the administrative control console, room selector switch or DTMF intercom handset. System shall support distribution to any of 31 distribution zones, individual rooms or combination thereof.
      f. Paging announcements shall be distributed from the control console on an Emergency All Call, All Call, All-Call multiple zone, or individual basis to classroom speakers.
      g. Any control console in the system shall have the ability to be designated as the “current console” and have the incoming calls from room stations, enunciate at that specific console. This function shall be programmed from the control console and shall allow for simple transfer of the “current console” assignment to any other console in the system.
      h. The console shall also provide the ability for the operator to place on hold, or clear any incoming calls registered in the system from the console keypad.
      i. Facilities for activating and controlling remote devices from the control console keypad. The system shall control the operation of external bells, utilizing the internal time clock within the system.
      j. Capabilities for user programming of alphanumeric architectural room numbers from the control console. The system shall be capable of using 2, 3, 4 digit number, or a letter (A = I) and a 3 digit number. The number for both the classroom speaker and the telephone shall be the same.
      k. The console shall retain the last room number dialed until another room number is dialed or previous call is cancelled.
      l. Ability to manually distribute tone signals on an all-call basis from the keypad of the Administrative Control Console cabinet.
      m. The console shall have the ability to program or change all of the operational characteristics of the Intercom/PA system.
   2. Call Switches
      a. The call switch shall be Telecor model CS-1 call switch. Furnish and install where indicated on the plans.
      b. The unit shall be momentary push to talk switch, mounted on a 1-gang brushed stainless steel plate, suitable for flush or surface mounting on a standard single-gang back box with 3-9/32” mounting centers
   3. Call Switch with Integrated Speaker
      a. Provide a Telecor ICS-3A local talk back function.
      b. The unit shall be stainless steel and contain the necessary speaker.
   4. Volume Control

a. A volume control dial shall be included with each call switch in administrative and office areas. See drawings for locations.

b. The volume control dial shall be mounted inline, directly above the call switch.

c. The volume control dial shall be the Atlas AT-10 or approved equal.

d. The volume control dial shall be compatible with the Telecor system architecture.

5. Rugged Call Switches
   a. In areas that are a hostile or rugged environment a tamper-proof call switch shall be provided. Furnish and install Telecor Model SCS-1 or approved alternate Telecor model.
   b. The unit shall be tamper-proof in design and construction with the faceplate being fabricated from 11-gauge stainless steel with a brushed, mar resistant surface.
   c. The switch actuator shall be manufacture from solid metal and connected to the face plate by a pair of welded studs. The actuator shall activate a momentary contact switch whose movement shall be limited by a mechanical stop to prevent damage caused by heavy impact.
6. Speakers
   a. The loudspeaker assembly shall be the Telecor STB-11 or approved alternate Telecor model
   b. Drop-in style speaker shall be Telecor STB-5 or approved alternate.
   c. The loudspeaker size shall be 8 inches in diameter and have a power handling capacity of 15 watts. The voice coil shall be of high-temperature bonded construction, be one inch in diameter and have an impedance of 8 ohms.
   d. The speaker shall have a frequency range of at least 50 Hz to 15,000 Hz and an axial sensitivity of 91 dB at 4 ft.., with a 1 watt input signal @ 1000Hz.
   e. The loudspeaker shall be equipped with a factory wired 25/70 volt line-matching transformer. The transformer shall have the primary taps at ¼, ½, 1, 2, and 4 watts.
   f. The insertion loss shall be no greater than 1.0 dB. The transformer shall be mounted to the speaker with the secondary leads soldered to the speaker terminals.
   g. The assembly shall include a baffle constructed of 22 gauge, cold-rolled steel finished with a mar-resistant white, semi-gloss, epoxy coating. The baffle shall have a diameter of 13". The STB-11 shall mount to a T8 support bridge, used to attach the assembly to suspended ceilings. The support bridge will accept an enclosure, model H8, to provide a protective enclosure. The H8 enclosure shall attach to the support bridge with appropriate mounting screws.
7. Horn Loudspeaker
   a. The horn style loudspeaker shall be a Telecor model A-15T or approved equal. Furnish and install as indicated on the plans.
   b. Flush style loudspeakers shall be Atlas Sound VTF 152UCN or approved equal.
   c. The horn shall be a double re-entrant type, with a flared bell and an integral compression driver rated for 15 watts of continues audio power. The frequency response shall be 375 -14,000Hz. Nominal sensitivity shall be such that a sound pressure level of 110 dB at 1000 Hz (on axis) at distance of one meter is produced with an input of one watt. Sound dispersion shall be no less than 100 degrees, regardless of the mounting position.
   d. The horn shall contain a weatherproof, built-in, 25/70 volt line matching transformer. Power taps shall be at 0.48, 0.94, 1.8, 7.5 or 15 watts for a 25V line and 1, 2, 3.8, 7.5 or 15 watts for a 70 V line. The power taps shall be screwdriver adjustable. Impedance selection shall be 5,000, 2500, 1300, 666, 333, 87, or 45 ohms.
   e. The unit shall include a die-cast universal mounting bracket, allowing the horn to be positioned both in the vertical and horizontal planes with a single adjustment. The wiring terminals and the screwdriver power tap shall be enclosed by a clear plastic cover for security and weather protection.
   f. The horn shall be finished in a grey epoxy. Dimensions shall be 9 1/4" deep with a diameter of 8”

g. Exterior speakers shall be individual homeruns.

8. Cable and Jacks
   a. Cables shall be plenum rated.
   b. PA Cable shall be yellow or approved equal.
   c. Headend to Call Switches shall be West Penn 25359B Plenum Rated Wire. Red/Black to speakers, Green/White to call switches.
   d. Hallway and exterior speaker runs shall utilize West Penn 25292B Plenum rated cable with no more than 10A per circuit.
   e. PA Cable must be presented to the school district Maintenance and Electrical Department for approval prior to installation.
9. Master Clock
   a. The system shall be a Primex 2400 master clock or approved equal.
10. Clocks
   a. Clocks shall be Telecor 2484 Digital, electric powered, corrected clocks.
   b. Clocks shall mount using a recessed backbox (Telecor) or a dual face housing.
   c. Gymnasium clocks shall have a protective cover.

2.3 ACCESSORIES

A. Additional
   1. Conduits shall be provided with fills that do not exceed 40% of the internal area of the conduit. Pull boxes shall be provided every 200' and every 270° of bend. All electronics shall be labeled at device ends and rack locations.
   2. Provide two 2" conduits from a 24" x 24" x 4" junction box located behind the sound rack to the ceiling above from home run classroom cable. The junction box shall be mounted with its center 16" above the fixed floor.
   3. Administrative type phones shall be provided in the main office and/or welcome center. These phones will be used to receive classroom calls as well as produce general paging and intercommunications conversations.
   4. Use color-coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with wiring diagrams.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Verification of Conditions
   1. Examine site conditions, with the Installer present, for compliance with requirements and other conditions affecting the performance of the Integrated Electronic Communications Network system.
   2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. System Installation
   1. Install system in accordance with NFPA 70 and other applicable codes. Install equipment in accordance with manufacturer's written instructions.
   2. Install wiring in raceway except within consoles, desks, and counters, and except in accessible ceiling spaces, and in gypsum board partitions, where cable-wiring method may be used. Use UL listed plenum cable in environmental air spaces including plenum ceilings. Conceal wiring except in unfinished spaces.
   3. Carefully match input and output impedance's and signal levels at signal interfaces. Provide matching networks where required.
   4. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
   5. All wires shall be laid down on terminal punch blocks and identified by the actual room location it serves. All the communications points shall be wired into this main distribution frame, laid down in sequence, and identified by which line it is on and the point position it

serves. All housings are to be located as specified and shown on drawings. Make installation in strict accordance with approved manufacturer's drawings and instructions.

6. The contractor shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.
7. Provide adequate length of conductors. Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars.
8. Provide physical isolation from each other for speaker-microphone, line-level, speaker-level, and power wiring. Run in separate raceways, or where exposed or in same enclosure, provide 12 inch minimum separation between conductors to speaker-microphones and adjacent parallel power and telephone wiring. Provide physical separation as recommended by equipment manufacturer for other Integrated Electronic Communications Network system conductors.
9. Make splices, taps and terminations on numbered terminal punch blocks in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.
10. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.
11. Wherever walls, ceilings, floors, or other building finishes are cut for installation, repair, restore, and refinish to original appearance.

3.3 FIELD QUALITY CONTROL

A. Site Tests
1. Contractor to provide services of a duly factory authorized service representative for this project location to supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.

B. Inspection
1. Contractor to make observations to verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Provide a list of final tap settings of paging speaker line matching transformers.

3.4 ADJUSTING

A. System Levels
1. When requested by the Design consultant within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, resetting matching transformer taps, and adjusting controls to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

3.5 CLEANING

A. System Appearance
1. Prior to final acceptance, clean system components and protect from damage and deterioration.

3.6 As-Builts

A. As builts shall be supplied in electronic CAD and hardcopy format and must show all devices, equipment, cable routing, labels and cables.

-END OF SECTION 27 50 00-

SECTION 28 10 00
ACCESS AND INTRUSION SYSTEMS

PART 1 - GENERAL

1.1 REQUIREMENTS

A. The general provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this Section.

1.2 SUMMARY

A. Provide a complete and fully operational Intrusion Detection System as described herein and the contract drawings.

B. Provide a complete and fully operational Access Control System and entry door video intercom system as described herein and the contract drawings.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

1. The Access Control and Intrusion Detection Systems Shall consist of the following:

a. Base panel

b. Expansion modules

c. Keypads

d. Annunciators

e. Motion Detectors

f. Door Contacts

g. Card Readers

h. Control Panels

i. Workstations

j. Servers

k. Power Supplies

l. Communication Modules

m. Software

n. Programming

o. Door Stations

p. Interior Stations

B. Performance Requirements

1. The Intrusion Detection System will alert and record movement throughout the facility that is both authorized and unauthorized.

2. The Access Control System will allow or deny entry based on credential and programming.

3. The Entry Door Video Intercom will provide audio and visual two-way communication and door lock release.
4. These systems shall be tied to other systems at the facility.
5. These systems shall be accessible via the Local Area Network and Wide Area Network.
6. The systems shall be capable of communications onsite as well as to remote locations.
7. The systems shall be controllable in the case of an emergency situation.
8. All systems shall operate on dedicated circuits with associated cabling in EMT.

1.4 CODES

A. Industry Codes, Standards and Methods shall be observed, including the following:

1. ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA-568.1-D: Commercial Building Telecommunications Cabling Standard
3. ANSI/TIA-568-C.2: Balanced Twisted Pair Cabling and Components Standard
4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
5. ANSI/TIA-569-D: Telecommunications Pathways and Spaces
6. ANSI/TIA-570-C: Residential Telecommunications Cabling Standard
7. ANSI/TIA-606-B: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
8. ANSI/TIA-607-C: Commercial Building Grounding and Bonding Requirements for Telecommunications
9. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
10. ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
11. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
12. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.5 RELATED SECTIONS

A. Division 08 Door Hardware

B. Division 26 Electrical Systems

1.6 SUBMITTALS

A. Product Data catalog sheets with specific devices highlighted.

B. Shop Drawings with a detailed riser detail shall be provided. Device locations as well as cable paths will also be provided.

C. Quality Assurance/Controls Submittals

1. Design Data for the system shall be submitted with the proposed submittals.
2. Upon completion of the installation, test reports shall be submitted to verify that the system is fully operational and functioning properly.
3. Certificates of designer and installer shall be submitted with job submittals.
4. Manufacturer's Instructions shall be followed and incorporated in the design of the system.

D. As Built drawings must be supplied to the owner and include full system layout for each system.

E. Owner's Manuals and Operation manuals complete with all codes and passwords necessary to control and maintain the system must be supplied prior to completion.

1.7 QUALITY ASSURANCE

A. A manufacturer's authorized distributor and installation contractor for the specified system shall install the security intrusion detection system. The installation shall include wiring, components, connections, adjustments, testing and certification. The Electrical Trade shall provide conduit, junction boxes and pull boxes as indicated and required by the security access control system manufacturer's drawings or trade instructions.

B. Regulatory Requirements

1. All equipment and materials for this system shall be listed by Underwriter's Laboratories, Inc. (UL), bear the UL label, and shall be installed in accordance with all requirements of the National Electrical Code (NEC), all state and local codes, and these Specifications.

2. Equipment shall be constructed in accordance with National Electrical Manufacturer's Association (NEMA) standards.

C. The security intrusion detection system contractor shall furnish a list of similar or equal installations and demonstrate five (5) years certifiable experience in this type of work.

1.8 WARRANTY

A. The intrusion system and entry door video intercom shall be under warranty for a period of two (2) years upon the acceptance of the owner.

1.9 MAINTENANCE

A. This contractor shall coordinate with owner to determine the acceptable quantities of spare parts.

B. Upon the completion of the factory two (2) year warranty, a maintenance contract will be negotiated between the intrusion system trade and the owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The Intrusion Detection System shall be Ademco.

B. The Access Control System shall be provided by other. Only Pathways are included in this scope of work.

C. The basis of design for the Video Entry Phone System shall be AIPHONE.

2.2 EQUIPMENT

A. Access Control System

1. LNL-1100-I8 Input module

2. LNL-1200-R8 Output control module

3. LNL-3300-GCM Intelligent System controller

4. LNL-500 Intelligent System Controller

5. LNL-1380-ACM Reader Interface Module

6. LNL-1300e Flexible Network-Connected Door I/O Module

7. Lenel Proximity Card Readers

8. Lenel Access Cards
9. OnGuard Watch Web-based system status monitor
10. OnGuard ID Credential Center
11. OnGuard Web-Based Application
12. OnGuard 7.3 Security Management System
13. Lenel Enclosures
14. Wiegand Reader Board
15. Battery Backup
16. Sentrol 1076D-N Recessed DPDT Contact
17. Lenel Power Supplies
18. Cat 6 UTP
19. 6 conductor Card Reader Cabling
20. Cabling per manufacturer's specifications.

B. Intrusion Detection Equipment
1. Control Panel Ademco Vista 250
2. Zone Expander Module
    a. 8-zone wired expander
    b. Supports main control panel
    c. Increases zone total from 8 to 16
3. Intelligent Relay Module
    a. 4204 for Contact Closure
4. IP / GSM Communicator
    a. Honeywell IPGSM-4G
5. Printer Interface Module
    a. Allows connection of a serial printer (300 baud) for local output of system log
6. Keypad
    a. 2-line by 16-character display for English zone descriptors and system status indications
    b. Large supertwist backlit LCD display provides wide viewing angle and exceptional readability
    c. Dedicated function keys to minimize keystrokes
    d. Convenient 4-wire installation
7. Siren
    a. 8 ohm indoor speaker
    b. 15 Watt continuous, 20 Watt peak
    c. Siren driver

8. Short Range Motion Detector
    a. Bosch DS820
    b. Bosch DS835
    c. With B328 mounting plate
9. Long Range Motion Detector
    a. Range: 100' x 20'
    b. Bosch DS860
    c. With B328 mounting plate
10. Surface Mount Contact
    a. Surface mount reed switch
    b. 22 mm gap
    c. 46 cm leads speed installation
    d. UL listed
    e. Color, white
11. Recessed Mount contact
    a. 9.5 MM recessed reed switch
    b. 46 cm leads speed installation
    c. 9.5 mm gap end to end
    d. UL listed
    e. Color, white
12. Overhead Door Contact
    a. Shock absorbing design
    b. Adjustable L bracket installation
    c. 60 cm armored cable
    d. Nominal Gap = 51 mm
13. Access Module
    a. Input Voltage: 10.5 VDC – 14.5 VDC
    b. Input Currency (Standby): 22 mA
    c. Input Current (During remote access, voice prompt playing): 50mA
    d. Input Current (During local access. voice prompt playing): 154mA
    e. Operating Temperature: 32°F to 122°F (0°C to + 50°C)
    f. Storage Temperature: -40°F to 158°F (-40°C to + 70°C)
14. Printer

15. Downloader Software
    a. Fully Compatible with LAN and pc requirements
    b. Simultaneously downloads from multiple workstations
    c. Complete Account Change/History
    d. Seamless DOS Conversion
    e. Advanced Error Check
    f. On-Screen Help Exclusive Panel Feature Search
    g. Unlimited System Templates
    h. Multiple User Definable Fields
16. Cabling – Per manufacturer's Specifications
    a. Wire gauge sized for length of cable run
        (1) 18/2 AWG
        (2) 18/4 AWG
        (3) 18/6 AWG
17. AIPHONE Door Entry System
    a. AIPHONE JP-DVF-RP10 Door Station
    b. AIPHONE JP-4MED Video Master Station
    c. AIPHONE JP-4HD Sub Station
    d. AIPHONE JP-8Z Distribution Amplifier
    e. AIPHONE PS-2420UL Power Supply
    f. AIPHONE KAW-D 30° Mullion Mount
    g. AIPHONE KMB-45 45° Mullion Mount
    h. AIPHONE SBX-IDVFRA Surface Box
    i. Associated cables, connectors and mounting equipment.
    j. See drawings for pathway locations and sizes.
    k. All pathways shall have pull strings left intact.

PART 3 - EXECUTION

3.1 EXAMINATION

A. This contractor shall visit the site prior to installation of the systems to verify site conditions.

3.2 INSTALLATION

A. This Contractor as directed by the equipment manufacturer shall make all low-voltage wiring and connections.

B. This Contractor shall label all access control and intrusion detection system junction boxes covers with the zone numbers contained therein.

C. This Contractor under the direct supervision of the Owner's technical staff shall perform the installation and final connections of all components and wiring.

D. All horizontal low voltage field-wiring penetrations through new and/or existing walls shall be sleeved. Minimum sleeve size shall be 3/4 inch. All sleeves shall be bushed both sides.

E. Devices

1. All access control and intrusion system devices shall be installed as per the manufacture's installation guides.

F. Field Wiring

1. All vertical low voltage field wiring shall be installed by this Contractor in 1/2-inch conduit and/or surface metal raceway as shown on the Drawings.
2. All horizontal, low voltage field wiring shall be run at right angles to the building structure.
3. All horizontal low voltage field wiring to be installed in areas without a ceiling or in areas without an accessible ceiling shall be installed by this Contractor in 1/2-inch conduit. Conduit is not required in areas designated on the Drawings as Electric/Communications rooms or closets.
4. All horizontal low voltage field wiring to be installed in areas with accessible ceilings shall be installed by this Contractor bundled together and run exposed above the ceilings. Bundles shall be supported by "J" hooks mounted not more than four (4) feet on center. "J" hooks to be dedicated to the wiring specified in this specification section.
5. All horizontal low voltage field wiring shall be installed below the roof/floor structural supports (joists, beams, girders, etc.) wiring installed between the structural supports mentioned above and the roof or floor deck will not be acceptable.
6. This Contractor with insulated crimp wire connections shall make all low voltage wiring terminations. All low voltage field-wiring interconnections shall be made in junction boxes. All junction box covers shall be stenciled for distinct identification.
7. All conduit, device mounting boxes, junction boxes, and line voltage wiring shall be furnished and installed by this Contractor.
8. All wiring shall be checked and tested by this Contractor to insure the system is free from grounds, opens, and shorts.

3.3 ADJUSTING

A. Devices shall be adjusted/calibrated once system is operational to ensure proper coverage areas, system integrations and full functionality of the systems with other systems.

3.4 AS-BUILTS

A. As-built documents shall be provided in hardcopy and electronic CAD format and must clearly show all devices, equipment, labeling and cables.

3.5 DEMONSTRATION

A. Furnish to the Owner's designated representative eight (8) hours of on-the-job technical service instructions in the operating, maintenance, and troubleshooting of the system.

Contact ID

ACCOUNT# Subscriber Name _____

CHOOSE ONE:

□ **ADDENDUM** TO A NEW SUBSCRIBER MONITORING AGREEMENT.
□ **CHANGE** TO DATA ON AN EXISTING SUBSCRIBER ACCOUNT.

NOTE: UNLESS OTHERWISE INDICATED, THE DEFAULT CALLBACK 0PTI0N FOR RESTORE IS **LOG ONLY**; **TROUBLE IS DEALER ONLY**.

PLEASE INDICATE CALLBACK OPTION. EXCLUSION OF THIS INFORMATION MAY DELAY THE PROCESSING OF A SUBSCRIBER MONITORING AGREEMENT. IF YOU HAVE ANY QUESTIONS, PLEASE CONTACT YOUR REPRESENTATIVE.

PANEL: □ADEMCO □NAPCO □FBI □APEX OTHER (SPECIFY)_____
PARTITIONED?: □ NO □ YES (DEFINE BELOW)

1	5
2	6
3	7
4	8

EVENT QUAL.	EVENT CODE	PARTITION	ZONE# USER#	ZONE DESCRIPTION / USER NAME	CALLBACK OPTION	Ax

-END OF SECTION 28 10 00-

SECTION 28 31 11
DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Remote annunciator.
8. Addressable interface device.
9. Digital alarm communicator transmitter.

B. Related Requirements:

1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.

b. Show field wiring required for HVAC unit shutdown on alarm.
c. Locate detectors according to manufacturer's written recommendations.

12. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.
b. NICET-certified, fire-alarm technician; Level III minimum.
c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to building Owner’s Representative at the time of system acceptance:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment.
d. Riser diagram.
e. Record copy of site-specific software.
f. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

    1) Equipment tested.
    2) Frequency of testing of installed components.
    3) Frequency of inspection of installed components.
    4) Requirements and recommendations related to results of maintenance.
    5) Manufacturer's user training manuals.

g. Manufacturer's required maintenance related to system warranty requirements.
h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.
i. Point-to-point diagrams of the entire Life Safety System as installed. This shall include all connected Smoke Detectors and addressable field modules. All drawings shall be provided in CAD and supplied in standard DXF format. Vellum plots of each sheet shall also be provided. A system generated point-to-point diagram is required to ensure accuracy.

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.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.6 WARRANTY

A. Warranty: Warranty all materials, installation and workmanship for three (2) years from date of acceptance, unless otherwise specified. A copy of the manufacturers' warranty shall be provided with close-out documentation and included with the operation and installation manuals.

1. Manufacturer shall guarantee the system equipment for a period of two (2) years from date of final acceptance of the system.

2. The Contractor shall guarantee all wiring and raceways to be free from inherent mechanical or electrical defects for two (2) years from date of final acceptance of the system.
3. Upon completion of the installation of fire alarm system equipment, the Contractor shall provide to the architect a signed written statement, substantially in form as follows: "The undersigned, having engaged as the Contractor on the Project confirms that the fire alarm system equipment was installed in accordance with the wiring diagrams, instructions and directions provided to us by the manufacturer."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. The Fire Alarm/Life Safety System supplied under this specification shall be a microprocessor-based network system. All Control Panel Assemblies and connected Field Appliances shall be both designed and manufactured by the same company, and shall be tested and cross-listed as compatible to ensure that a fully functioning Life Safety System is designed and installed.

B. Manufacturers: Subject to compliance with requirements, provide only products listed:

1. Edwards EST3,
2. Silent Knight by Honeywell

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. The system shall automatically display on the control panel Liquid Crystal Display the first event of the highest priority by type. The priorities and types shall be alarm, supervisory, trouble, and monitor.

1. The system shall have a Queue operation, and shall not require event acknowledgment by the system operator. The system shall have a labeled color coded indicator for each type of event; alarm - red, supervisory - yellow, trouble - yellow, monitor - yellow. When an unseen event exists for a given type, the indicator shall be lit.
2. For each event, the display shall include the current time, the total number of events, the type of event, the time the event occurred and up to a 42 character custom user description.
3. The user shall be able to review each event by simply selecting scrolling keys (up-down) for each event type
4. New alarm, supervisory, or trouble events shall sound a silencing audible signal at the control panel.

B. Operation of any alarm initiating device shall automatically:

1. Update the control/display as described above (A.1.)
2. Sound all audible speaker appliances with a prerecorded message. Audible devices shall have the ability to be silenced.
3. Activate all strobe appliances throughout the facility. ALL STROBE APPLIANCES SHALL BE SYNCHRONIZED WITH EACH OTHER IN ANY LOCATION WITH TWO OR MORE DEVICES IN A COMMON FIELD OF VIEW. Visual devices shall be non-silenced unless the system is successfully reset.
4. Operate control relay contacts to shutdown all HVAC units serving the floor of alarm initiation.

5. Operate control relay contacts to return all elevators that serve the floor of alarm initiation to the ground floor. If the alarm originates from the ground floor, operate control circuits contacts to return all elevators to the floor above or to a level as directed by the local fire department.
6. Operate control relay contacts to release all magnetically held smoke doors throughout the building.
7. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.
8. Transmit an alarm condition, via the integral central station communicator, to central station/Local Fire Department (as required by the AHJ).

C. Elevator smoke and heat detector sequences shall comply with the ANSI A17.1 requirements for main/alternate floor recalls, and shunt trip activations.

D. Activation of a sprinkler supervisory initiating device shall:

1. Update the control/display as described above (A.1.)
2. Transmit a supervisory condition, via the integral central station communicator, to central station/Local Fire Department (as required by the AHJ).
3. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.

E. The entire fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or disarrangement of system wiring and shorts across alarm signaling wiring shall automatically:

1. Update the control/display as described above (A.1.)
2. Transmit a trouble condition, via the integral central station communicator, to central station/Local Fire Department (as required by the AHJ).
3. Visually and audibly annunciate a general trouble condition, on the remote annunciator panels. The visual indication shall remain on until the trouble condition is repaired.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways 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."

2.4 FIRE-ALARM CONTROL UNIT

A. Coordinate "General Requirements for Fire-Alarm Control Unit" Paragraph below with implementation details and Drawings. Addressable horns are available for notification-appliance circuits; insert a subparagraph if required. UL 864 requires compliance with software integrity requirements. The fire alarm control panels shall be General Electric Edwards Systems Technology (EST) Type EST3 and shall incorporate all control electronics, relays, and necessary modules and components in a surface mounted cabinet. The operating controls and zone/supervisory indicators shall be located behind locked door with viewing window. All control modules shall be labeled, and all zone locations shall be identified. The cabinet shall be steel, with a gray finish. The assembly shall contain a base panel, system power supply and battery charger with optional modules suitable to meet the requirements of these specifications.

B. System circuits shall be configured as follows: Addressable analog loops Class B; Notification Appliance Circuits Class B.

C. Single stage operation.

D. The system shall be supervised, site programmable, and of modular design with expansion modules to serve up to 192 detectors and 188 remote modules, and four notification appliance circuits (NACs) convertible to power risers to serve remote multiple NAC modules for zoned signal applications.

E. The system shall store all basic system functionality and job specific data in non-volatile memory. The system shall survive a complete power failure intact.

F. The system shall have built-in automatic system programming to automatically address and map all system devices and provide a minimum default single stage alarm system operation with support of alarm silence, trouble silence, drill, lamp test, and reset common controls.

G. The system shall allow down loading of a job specific custom program created by system application software. It shall support programming of any input point to any output point. The system shall support the use of Bar Code readers to assist custom programming functions. It shall allow authorized customization of fundamental system operations using initiating events to start actions, timers, sequences and logical algorithms.

H. The system shall support distributed processor intelligent detectors with the following operational attributes; integral multiple differential sensors, automatic device mapping, electronic addressing, environmental compensation, pre-alarm, dirty detector identification, automatic day/night sensitivity adjustment, dual normal/alarm LEDs, relay bases, and isolator bases.

I. The system shall use full digital communications to supervise all addressable loop devices for placement, correct location, and operation. It shall allow swapping of "same type" devices without the need of addressing and impose the "location" parameters on replacement device. It shall initiate and maintain a trouble if a device is added to a loop and clear the trouble when the new device is mapped and defined into the system.

J. The system shall have a UL Listed Detector Sensitivity test feature, which will be a function of the smoke detectors and performed automatically every 4 hours.

K. The system shall support 100% of all remote devices in alarm and provide support for a 100% compliment of detector isolator bases.

L. All panel modules shall be supervised for placement and return trouble if damaged or removed.

M. The system shall have a CPU watchdog circuit to initiate trouble should the CPU fail.

N. The system evacuation signal rate shall be continuous, or March time at 120 PPM.

O. Provide a signal silence inhibit feature set to enter integer time between 0-99 minutes and an automatic signal silence timer set to enter integer time between 0-99 minutes. Audible notification appliances shall be affected by signal silence features. Visual signal appliance shall not be affected by signal silence features.

P. The system program shall meet the requirements of this project, current codes and standards, and satisfy the Office of Life Safety.

Q. Passwords shall protect any changes to system operations.

R. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection. The power supply shall provide internal power and 24 Vdc at 4A continuous for notification appliance circuits. The power supply shall be capable of providing 10A to output circuits for a maximum period of 50 ms. Auxiliary power shall be 24 Vdc at 500 mA. All outputs shall be power limited. The battery shall be sized to support the system for [24 or 4] hours of supervisory and trouble signal current plus general alarm for 5 minutes.

S. The LCD Display Module shall be of membrane style construction with a 4 line by 20 character Liquid Crystal Display. The LCD shall use supertwist technology and backlighting for high contrast visual clarity. In the normal mode display the time, the total number of active events and the total number of disable points. In the alarm mode display the total number of events and the type of event on display. Reserve 40 characters of display space for user custom messages. The module shall have visual indicators for the following common control functions; AC Power, alarm, supervisory, monitor, trouble, disable, ground fault, cpu fail, and test. There shall be common control keys and visual indicators for; reset, alarm silence, trouble silence, drill, and one custom programmable key/indicator. Provide four pairs of display control keys for selection of event display by type (alarm, supervisory, monitor and trouble) and forward / backward scrolling through event listings. The operation of these keys shall be integrated with the related common control indicators to flash the indicators when undisplayed events are available for display and turn on steady when all events have been displayed. Allow the first event of the highest priority to capture the LCD for display so that arriving fire fighters can view the first alarm event "hands free". Provide system function keys; status, reports, enable, disable, activate, restore, program, and test. The module shall have a numeric keypad, zero through nine with delete and enter keys.

T. The Main Controller Module shall control and monitor all local or remote peripherals. It shall support the LCD Display Module, power supply, remote LCD and zone display annunciators, strip and carriage printers, and support communication interface standard protocol (CSI) devices such as color computer annunciators and color graphic displays. The RS-485 port shall be capable of supporting up to 32 remote annunciators. The MCM shall provide one loop controller circuit, two notification appliance circuits, and common form 'C' contacts for alarm, supervisory, and trouble. Contact ratings shall be 24Vdc at 1A.

2.5 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. It shall be possible to address each Signature Series fire alarm pull station without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The manual stations shall have a minimum of 2 diagnostic LEDs mounted on their integral, factory assembled single or two stage input module. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The station shall be capable of storing up to 24 diagnostic codes that can be retrieved for troubleshooting assistance. Input circuit wiring shall be supervised for open and ground faults. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F (0°C to 49°C), Humidity: 0-93% RH, non-condensing.

1. Manual Fire Alarm Stations, SIGA-278: Provide intelligent single action, single stage fire alarm stations SIGA-270. The fire alarm station shall be of metal construction with an internal toggle switch. Provide a locked test feature. Finish the station in red with silver “PULL IN CASE OF FIRE” English lettering. The manual station shall be suitable for

mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Provide SIGA2-PS, Provide intelligent photoelectric smoke detectors. The analog photoelectric detector shall utilize a light scattering type photoelectric smoke sensor to sense changes in air samples from its surroundings. The integral microprocessor shall dynamically examine values from the sensor and initiate an alarm based on the analysis of data. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC. The photo detector shall be rated for ceiling installation at a minimum of 30 ft (9.1m) centers and be suitable for wall mount applications. The photoelectric smoke detector shall be suitable for direct insertion into air ducts up to 3 ft (0.91m) high and 3 ft (0.91m) wide with air velocities up to 5,000 ft/min. (0-25.39 m/sec) without requiring specific duct detector housings or supply tubes.

   a. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The photo detector shall be suitable for operation in the following environment:

      1) Temperature: 32ºF to 120ºF (0ºC to 49ºC)
      2) Humidity: 0-93% RH, non-condensing
      3) Elevation: no limit

2. Provide standard detector mounting bases SIGA-SB suitable for mounting on North American 1-gang, 31/2" or 4" octagon box and 4" square box. The base shall, contain no electronics, support all Signature Series detector types and have the following minimum requirements:

   a. Removal of the respective detector shall not affect communications with other detectors.
   b. Terminal connections shall be made on the room side of the base. Bases which must be removed to gain access to the terminals shall not be acceptable.
   c. The base shall be capable of supporting one (1) Signature Series SIGA-LED Remote Alarm LED Indicator. Provide remote LED alarm indicators where shown on the plans..

B. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Duct Detector Housing, SIGA-SD: Provide model SIGA-SD Low profile intelligent addressable DUCT smoke detector as indicated on the project plans. Provide for variations in duct air velocity between 100 and 4,000 feet per minute and include a wide sensitivity range of .79 to 2.46%/ft. Obscuration. Include one Form-C shut down relay rated 2.0 amps @ 30 Vdc and also include slave high contact relays if required. Provide an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet. The addressable DUCT housing shall be suitable for extreme environments, including a temperature range of –20 to 158 degrees F (-29 to 70 degrees Celsius) and offer a harsh environment gasket option. Provide Remote Alarm LED Indicators SIGA-LED and/or remote test station model SD-TRK as indicated on the project plans.

2.7 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Addressable Carbon Monoxide (CO) Detector, EST model SIGA2-COS with audible sounder base. Provide intelligent addressable Carbon Monoxide Detector with Temporal 4 Audible Base. The CO detection element shall indicate a trouble condition at the FACP signaling end of life and the CO element of the detector shall be field replaceable. It shall be programmed at the main control panel as a supervisory indication and transmit a separate supervisory signal to the central station. The CO detector shall be UL 2075 listed.

2.8 MONITOR MODULES

A. General Requirements for Monitor Modules:

1. Single Input Module, SIGA-CT1 (Waterflow Detectors, Tamper Switches etc.): Provide intelligent single input modules SIGA-CT1. The Single Input Module shall provide one (1) supervised Class B input circuit capable of a minimum of 4 personalities, each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The single input module shall support the following circuit types:

   a. Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.),
   b. Normally-Open Alarm Delayed Latching (Waterflow Switches),
   c. Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.),
   d. Normally-Open Active Latching (Supervisory, Tamper Switches).

2. Dual Input Module, SIGA-CT2: Provide intelligent dual input modules SIGA-CT2. The Dual Input Module shall provide two (2) supervised Class B input circuits each capable of a minimum of 4 personalities, each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The dual input module shall support the following circuit types:

   a. Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.),
   b. Normally-Open Alarm Delayed Latching (Waterflow Switches),
   c. Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.),
   d. Normally-Open Active Latching (Supervisory, Tamper Switches).

3. Single Input Signal Module, SIGA-CC1: Provide intelligent single input signal modules SIGA-CC1. The Single Input (Single Riser Select) Signal Module shall provide one (1) supervised Class B output circuit capable of a minimum of 2 personalities, each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" (64mm) deep 2-gang boxes and 1 ½" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes. The single input signal module shall support the following operations:

   a. Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A).

4. Dual Input Signal Module, SIGA-CC2: Provide intelligent dual input signal modules. The Dual Input (Dual Riser Select) Signal Module shall provide a means to selectively connect one of two (2) signaling circuit power risers to one (1) supervised output circuit. The module shall be suitable for mounting on North American 2- 1/2" (64mm) deep

2-gang boxes and 1- 1/2" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes. The dual input signal module shall support the following operation:

a. Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A, 25 Vrms @ 50w or 70 Vrms @ 35w of Audio)

5. Control Relay Module, SIGA-CR: Provide intelligent control relay modules SIGA-CR. The Control Relay Module shall provide one form "R" dry relay contact rated at 2 amps @ 24 Vdc to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware. The control relay module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.
6. Audible Detector Mounting Base, SIGA-AB4GT. The sounder base shall be capable of two tones, Temporal 3 for a fire condition and Temporal 4 for a Carbon monoxide condition. The tones shall be fully programmable and also synchronize the sound with other sounder bases. The system shall be UL2017 listed for dual signaling for this purpose.
7. Monitor Module, SIGA-MM1: Provide intelligent monitor modules. The Monitor Module shall be factory set to support one (1) supervised Class B Normally-Open Active Non-Latching Monitor circuit. The monitor module shall be suitable for mounting on North American 2- 1/2" (64mm) deep 1-gang boxes and 1- 1/2" (38mm) deep 4" square boxes with 1-gang.
8. Universial Class A/B Module, SIGA-UM: Provide intelligent Class A/B modules. The Universal Class A/B Module shall be capable of a minimum of fifteen (15) distinct operations. The module shall be suitable for mounting on North American 2 1/2" (64mm) deep 2-gang boxes and 1 1/2" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes. The universal class A/B module shall support the following circuit types:

a. Two (2) supervised Class B Normally-Open Alarm Latching.
b. Two (2) supervised Class B Normally-Open Alarm Delayed Latching.
c. Two (2) supervised Class B Normally-Open Active Non-Latching.
d. Two (2) supervised Class B Normally-Open Active Latching.
e. One (1) form "C" dry relay contact rated at 2 amps @ 24 Vdc.
f. One (1) supervised Class A Normally-Open Alarm Latching.
g. One (1) supervised Class A Normally-Open Alarm Delayed Latching.
h. One (1) supervised Class A Normally-Open Active Non-Latching.
i. One (1) supervised Class A Normally-Open Active Latching.
j. One (1) supervised Class A 2-wire Smoke Alarm Non-Verified.
k. One (1) supervised Class B 2-wire Smoke Alarm Non-Verified.
l. One (1) supervised Class A 2-wire Smoke Alarm Verified
m. One (1) supervised Class B 2-wire Smoke Alarm Verified
n. One (1) supervised Class A Signal Circuit, 24Vdc @ 2A.
o. One (1) supervised Class B Signal Circuit, 24Vdc @ 2A

2.9 WATERFLOW/TAMPER MODULE

A. Waterflow/Tamper Module: SIGA-WTM waterflow/tamper modules. The Waterflow/Tamper Module shall be factory set to support two (2) supervised Class B input circuits. Channel A shall support a Normally-Open Alarm Delayed Latching Waterflow Switch circuit. Channel B shall support a Normally-Open Active Latching Tamper Switch. The waterflow/tamper module shall be suitable for mounting on North American 2 1/2" (64mm) deep 1-gang boxes and 1 1/2" (38mm) deep 4" square boxes with 1-gang covers.

2.10 NOTIFICATION APPLIANCES

A. General: All appliances shall be UL Listed for Fire Protective Service. All strobe appliances or combination appliances with strobes shall be capable of providing the “Equivalent Facilitation” which is allowed under the Americans with Disabilities Act accessibility guidelines (ADA(AG)), and shall be UL 1971, and ULC S526 Listed. All appliances shall be of the same manufacturer as the Fire Alarm Control Panel **(NO EXCEPTIONS)** specified to insure absolute compatibility between the appliances and the control panels, and to insure that the application of the appliances are done in accordance with the single manufacturers’ instructions. Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from **THE CONTROL PANEL MANUFACTURER** clearly stating that the control equipment (as submitted) is 100% compatible with the submitted Notification Appliances. The visual and audio/visual signaling devices shall be compatible with the 5820XL, 5495, 5496, 5499, or 5895XL as stated in the installation manuals and be Listed with Underwriters Laboratories Inc. per UL 1971 and/or 1638. Each indicating appliance circuit shall be electrically supervised for opens, grounds and short circuit faults, on the circuit wiring, and shall be so arranged that a fault condition on any indicating appliance circuit or group of circuits will not cause an alarm to sound. The occurrence of any fault will light the trouble LED and sound the system trouble sounder, but will not interfere with the proper operation of any circuit which does not have a fault condition. The notification appliance (combination audio/visual units only) shall produce a peak sound output of 90dba or greater as measured in an anechoic chamber. The appliance shall be capable of meeting the candela requirements of the blueprints presented by the Engineer and ADA. The appliance shall be polarized to allow for electrical supervision of the system wiring. The unit shall be provided with terminals with barriers for input/output wiring and be able to mount a single gang or double gang box or double workbox with the use of an adapter plate. The unit shall have an input voltage range of 19-30 volts.

B. Strobes, EG1RF-VM Series: Provide EST Series EG1RF-VM series low profile wall mounted strobes at the locations shown on the drawings. Provide EST Series EGC-S2VM series low profile ceiling mounted Strobes shall provide synchronized flash outputs. Strobe output shall be field selectable as indicated on the drawings in one of the following intensity levels; 15/75, 15cd, 30cd, 75cd or 110cd*. Low profile strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

C. Speakers and Speaker Strobes, Genesis Series: Provide speakers with a 4” cone, wall mounted as manufactured by EST, Cat. No. EG4-S7VM Genesis Series. Provide EGCF-S2VM and EGC-S7 for ceiling mounted applications. The rear of the speaker shall be completely sealed protecting the cone during and after installation. Screw terminals shall be provided for wiring and the speaker housings shall be red and include "FIRE" labeling. Speakers shall be provided for use with 70V systems and shall provide power taps at 1/4w, 1/2w, 1w, and 2w. Speakers shall provide UL confirmed 90 dBA sound output at 2w. Speakers shall mount in a North American 4” electrical box with extension ring using the 2 screws provided with ring. It must not be necessary to completely remove the screws to facilitate mounting.

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.12 TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

B. Equipment Mounting: Install fire-alarm control unit on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing: Comply with NFPA 72.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

G. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

3.2 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.
C. Exposed EMT shall be painted red enamel.

3.3 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.

5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
9. Supervisory connections at elevator shunt-trip breaker.
10. Supervisory connections at fire-extinguisher locations.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Provide machine printed address labels on all addressable devices to be visible from the floor.

C. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.7 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION AND TRAINING

A. The contractor shall compile and provide to the owners three (3) complete manuals on the completed system to include SITE SPECIFIC operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams and a manufacturer's suggested spare parts list. An operational Video, on DVD media, shall also be included.

B. In addition to the above manuals, the Electrical Contractor shall provide the services of the manufacturer's trained representative for **two (2)** separate calendar days for a period of four **(4) hours** per day to instruct the owners' designated personnel on the operation and maintenance of the entire system.

C. As-built drawings shall consist of the following:

1. Complete revision of all previously submitted drawings.
2. Point-to-point depiction of all device wiring on the device layout floor plans
3. One (1) set of B-size, laminated as-built drawings.
4. Two (2) sets of 30" x 42" 1/16" = 1' scale drawings showing all points of the fire alarm. One set shall be submitted with the closeout documents. Second set shall be mounted in frame with lexan cover. These drawings must be submitted to project Engineer for approval.

D. Turnover of all software database hard/soft copies shall be required. This shall include all possible programming software logs, diskettes or CDs containing exported project files, hard

copies of all device maps, the revision number of the version of programming utility used, and all required passwords.

3.9 FINAL TEST

A. Before the installation shall be considered completed and acceptable by the awarding authority, a test of the system shall be performed as follows:

1. The contractor's job foreman, a representative of the Owner, and the fire department shall operate every building fire alarm device to ensure property operation and correct annunciation at the control panel.
2. At least one half of all tests shall be performed on battery standby power.
3. Where application of heat would destroy any detector, it may be manually active.
4. The communication loops and the indicating appliance circuits shall be opened in at least two (2) locations per circuit to check for the presence of correct supervision circuitry.
5. When the testing has been completed to the satisfaction of both the contractor's job foreman and Owner, a notarized letter cosigned by each attesting to the satisfactory completion of said testing shall be forwarded to the Owner and the fire department.
6. The contractor shall leave the fire alarm system in proper working order, and without additional expense to the owner, shall replace any defective materials r equipment provided by him under this contract within one year (365 days) from the date of final acceptance by the awarding authority.
7. Prior to final test the fire department must be notified in accordance with local requirements.

- END OF SECTION 28 31 11 -

SECTION 31 10 00
CLEARING

PART 1 - GENERAL

1. 1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to clear the project site.

1.3 RELATED WORK

A. Refer to Section 31 20 00 "Earthmoving"

1.4 STANDARDS

A. Maryland Standards and Specifications for Soil Erosion and Sediment Control, current edition.

1.5 PROJECT CONDITIONS

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Existing Utilities: The locations of all existing utilities are approximate. These locations have been determined from field survey, public utility records and Owner records.

1. The Contractor shall be responsible for contacting "Miss Utility" and all Owner's or controlling agencies of existing utilities within the construction area for verification of locations, prior to beginning of work.
2. The Contractor shall be responsible for coordination of utility relocation or removal by others with all phases of construction activities.

1.6 SUBMITTALS

A. Submit written notification to public utility companies, at least one week prior to planned work, for disconnection of active utilities.

1.7 DEFINITIONS

A. Topsoil: A friable loam surface soil, free of subsoil, clay, lumps, weeds, roots, debris and stones exceeding one inch in any dimension.

1.8 CONSTRUCTION SURVEYS

A. Provide survey equipment and qualified personnel for construction surveys. Provide stakes and/or flag trees to designate the limits of clearing operations.

PART 2 - PRODUCTS

2.1 TEMPORARY TREE PROTECTION FENCING

A. In accordance with Maryland Standards and Specifications for Soil Erosion and Sediment Control, current edition, and as indicated.

B. Fence Posts: Steel "T" or "U" channel, with punched or riveted lugs for fence attachment.

1. Weight: 1.33 pounds per linear foot
2. Length: 66 inches
3. Bottom End Shape: Pointed
4. Finish: Rust inhibitive primer paint

C. Contractor's Option: Hardwood posts, two by two inches by 66 inches long, with pointed bottom ends.

D. Fence Fabric: Tensar Safety Barricade, manufactured by the Tensar Corporation, Morrow, Georgia.

1. Fabric Height: Four feet
2. Color: Safety Orange

E. Contractor's Option: Standard snow fence, used with steel posts.

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Existing Trees: Protect existing trees, indicated "To Remain", and existing trees beyond the indicated "Clearing and Grading Limits" from the following:
1. Cutting, breaking or skinning roots.
2. Skinning or bruising bark.
3. Stockpiling earth materials within drip line.
4. Stockpiling construction materials within drip line.
5. Vehicle parking within drip line.
6. Excessive pedestrian or vehicular traffic.

C. Temporary Tree Protection Fencing: Provide "Temporary Tree Protection" for trees indicated to remain, and as required for existing trees beyond the indicated "Clearing and Grading Limits". Install as indicated or required in accordance with the standards of the "Maryland Standards and Specifications for Soil Erosion and Sediment Control", and as noted.

1. Install posts, spaced no more than 6 feet on center, by driving plumb to 18-inch depth. Stretch fence fabric between posts and fasten securely to steel posts with tie wire. Fastenings for hardwood posts shall be tie wire or staples.

D. The Contractor shall provide a 'Watering Plan' submittal that identifies the frequency and rate of watering for review and approval. This will be required for all trees indicated "To Remain" during clearing and subsequent construction operations.

E. Repair or remove and replace trees indicated "To Remain" or located beyond the indicated "Clearing and Grading Limits" and damaged by clearing or subsequent construction operations, with new trees of equal species, caliper and quality, as directed by the Architect, at no increase to contract sum.

3.2 CLEARING

A. Clear the project site, removing trees and vegetation, within "Clearing and Grading Limits" indicated.

3.3 GRUBBING

A. Completely remove stumps, roots and debris, within "Clearing and Grading Limits" indicated, to minimum 12-inch depth below existing ground surface. Employ manual methods for grubbing around trees indicated "To Remain".

3.4 TOPSOIL STRIPPING

A. Strip topsoil, within "Clearing and Grading Limits" indicated. Remove heavy vegetation growth before stripping. Strip topsoil to all depths encountered. Strip topsoil to prevent intermingling with tree roots underlying subsoil.

1. Do not strip topsoil within the drip line of existing trees indicated "To Remain", or located beyond the indicated "Clearing and Grading Limits".

B. Stockpile topsoil, at locations approved by the Architect, until required for landscape development. Shape and grade stockpiles to prevent surface water ponding. Temporarily stabilize stockpiles as specified on the Soil Erosion and Sediment Control Drawings.

3.5 WASTE MANAGEMENT

A. Transport combustible and non-combustible waste materials from the project site to legal offsite disposal areas. Document legal offsite waste disposal areas. Burning of waste materials is prohibited.

- END OF SECTION 31 10 00 -

SECTION 31 20 00
EARTHMOVING

PART 1 - GENERAL

1.1 RELATED DRAWINGS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials, equipment and work required to perform earthwork and grading operations for site development.

1.3 TESTING AND INSPECTIONS

A. The Owner shall be responsible for providing a Maryland Registered Professional Soils Engineer for required testing and inspections.

B. Services of the Soils Engineer will not necessarily be on a full time basis, but will include the number of visits and tests required to observe the performance of all earthwork under this Section. If in the opinion of the Soils Engineer, any work performed under this Section does not meet the technical or design requirements stipulated for the work, the Contractor shall make all necessary readjustments to his approval.

C. All earthwork procedures shall be performed in the presence of the Soils Engineer. Give adequate (24 hours) notice when Soils Engineer's services are required.

1.4 RELATED WORK

A. Refer to Section 31 10 00 "Clearing".

1.5 CODES

A. Contractor shall comply with the applicable requirements of the governing agencies having jurisdiction.

1.6 DEFINITIONS

A. Excavation: Removal of earth materials to subgrade elevations indicated or specified.

B. Over-Excavation: Removal of earth materials, beyond subgrade elevations indicated or specified, without written authorization from the Architect.

C. Unsuitable Earth: Soft or unstable earth materials beyond limits of excavation indicated (e.g. muck, soft clays, organic soils, peat, etc.).

D. Fill: Placement of earth materials over existing ground surfaces to subgrade elevations indicated or specified.

E. Backfill: Placement of earth materials in excavations to subgrade elevations indicated or specified.

F. Soils Engineer: Shall be a Licensed Professional Engineer, currently registered in the State of Maryland, or shall be an authorized representative of such an engineer.

G. Rock: Defined as material that cannot be dislodged by a Caterpillar Model No. D-8N, heavy duty track-type tractor, rated at not less than 285 hp flywheel power and equipped with a single shank hydraulic ripper, capable of exerting not less than 45,000 lbs breakout force. Rock excavation includes up to 6-inches over-excavation below the required excavation depth. This definition of rock does not include materials such as hardpan, loose rock, concrete or other materials that can be removed by means other than drilling and blasting, but which for reasons of economy in excavating the Contractor chooses to remove by drilling and blasting.

1.7 SUBMITTALS

A. Density Test Results: The Contractor shall submit copies of the results of the specified density testing to the Owner's Representative for review and approval.

B. Submit location of product manufacture and of extraction/recovery of primary raw materials.

C. Submit recycled-content data, designating percentages of post-consumer and post-industrial recycled material.

D. For products having recycled content, documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

E. For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

1.8 PROJECT CONDITIONS

A. Existing Subsurface Conditions: All excavation materials shall be “unclassified”.

B. Existing Utilities: The locations of all existing utilities are approximate. These locations have been determined from field survey, public utility records and Owner records.

1. The Contractor shall be responsible for contacting "Miss Utility" and all Owner's or controlling agencies of existing utilities within the construction area for verification of locations, prior to beginning of work.

2. The Contractor shall be responsible for coordination of utility relocation or removal by others with all phases of construction activities.

1.9 CONSTRUCTION SURVEYS

A. Provide survey equipment and qualified personnel for construction surveys. Provide combined vertical and horizontal stakes required to perform earthwork operations to subgrade elevations indicated or specified.

1.10 EARTHWORK BALANCE

A. Perform all earthwork operations regardless of actual quantities encountered.

1. Excess materials shall be legally disposed of off project property.

2. Off-site borrow shall be provided at no increase to the Contract sum.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide products manufactured and of primary raw materials extracted/recovered within a 500-mile radius of the project site.

B. Fill Materials: Soils used as fill materials shall have Unified Soils Classification (ASTM D 2487) of ML or better, but shall exclude highly plastic clays or silts (MH-CH). Soil material for fill shall be free of organic matter or debris, waste materials, frozen materials, vegetable matter and rock or stones exceeding three inches in any dimension. No more than 15 percent of rocks or lumps shall be larger than 2½ inches in any dimension. Materials shall be non-frost susceptible soils, and shall have a liquid limit of less than 40 and a plasticity index of less than 12.

1. Fill material used within the top 12 inches of fill shall be free of rocks or stones exceeding one inch in any dimension.

2. Recycled concrete (RC-6) subbase may be used as fill material, except under building slab.

C. Backfill Material: As indicated for fill material.

D. Borrow Material: Off-site borrow, if required, shall be as specified for Fill Materials. Obtain and transport borrow material at no increase to the Contract sum.

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION

A. General: Provide protection to prevent settlement, movement, undermining of or erosion to existing site improvements, existing utilities, existing buildings, new site improvements, new buildings and new utilities.

B. Do not permit heavy equipment to pass over any utility until a minimum of two feet of compacted fill or backfill is placed over the top of utility.

C. Restore damage, at no increase to Contract sum, resulting from the lack of protection or improper installation of protective measures or careless execution of construction activities. Restoration work to be approved by the Soils Engineer and Owner's Representative.

3.2 EXISTING UTILITIES

A. Notify all public utility companies, 48 hours prior to the start of earthwork operations. Verify and mark horizontal utility locations prior to the start of earthwork operation. Manually excavate and expose utilities as earthwork operations approach marked locations.

B. Immediately notify the Owner’s Representative or the Architect in the event horizontal or vertical utility locations differ from locations indicated. Provide horizontal and vertical details of utility locations as directed by the Owner’s Representative or the Architect. Conflicts with construction to be determined by the Owner’s Representative or the Architect. Payment for correction of unforeseen conflicts with construction shall be by change order.

C. Coordinate public utility relocation work required for public utilities conflicting with construction. The Owner’s Representative or the Architect will provide directions and details required to relocate utilities conflicting with construction.

D. Do not disconnect or interrupt existing utilities serving existing facilities to remain without notification and authorization of the Architect or the Owner's representatives.

3.3 DEWATERING

A. Perform earthwork and grading operations to prevent surface or subsurface water from flowing into excavations, surface or subsurface water from flooding project site or adjacent property and water accumulations detrimental to stability of subgrades. Provide, install, operate and maintain all required pumps, sumps, discharge lines and related equipment.

3.4 EXCAVATION

A. Excavate materials encountered to subgrade elevations indicated or specified. All excavation is unclassified. Excavate materials regardless of the character of the materials encountered, at no increase to contract sum.

B. Blasting – Blasting on this site is acceptable, provided it is performed in accordance with MDOT-SHA Standards and Specifications. Specifically section TC-6.07. In addition, the Contractor shall coordinate all blasting efforts with the Owner so as not to impact the User. Lastly, the Contractor shall be responsible for all impacts that blasting has on the adjacent buildings.

C. Subgrade Preparation: Upon completion of excavation activities, exposed subgrade shall be proofrolled utilizing a minimum 10-ton roller, in the presence of the Soils Engineer. Proofrolling shall not be performed during or following wet weather conditions. Any unsuitable materials discovered during proofrolling operations shall be removed and replaced as specified below. Upon completion of proofrolling activities and approval of the subgrade by the Soils Engineer, exposed subgrade shall be further prepared as follows:
   1. Unpaved Areas: Scarify subgrade to six-inch depth prior to topsoil placement.
   2. Paved Areas: Scarify subgrade to twelve-inch depth and compact to 98 percent maximum dry density, compact the top 18” to 100% maximum dry density. Density test methods: ASTM D 698. Remove unsuitable earth, exhibiting excessive weaving during compaction operations, as specified.

3.5 OVER-EXCAVATION

A. Correct over-excavated areas as directed by the Soils Engineer. Remove unsuitable earth encountered as a direct result of over-excavation. Excavate and dispose of all unsuitable earth. Correct excavated area as directed.

3.6 UNSUITABLE EARTH

A. Immediately notify the Owner’s Representative or the Architect, and Soils Engineer in the event unsuitable earth is encountered during earthwork or subsequent construction operations. Stop all work within immediate area of unsuitable earth. Do not remove unsuitable earth until written authorization is obtained from the Owner’s Representative and proper measurements are obtained. Excavate and dispose of all unsuitable earth upon receipt of written authorization from the Owner’s Representative. Backfill excavated area as specified. Payment for unsuitable earth removal and associated backfill operations to be by change order.

3.7 EXCAVATED MATERIAL STORAGE

A. Stockpile select excavated materials required for fill and/or backfill operations. Stockpile locations are shown on the drawings and the stockpiles are not to exceed the plan view areas shown on the drawings. All Stockpile locations are to be approved by the Construction Manager. Shape and grade stockpiles to prevent ponding of surface water. Temporarily stabilize stockpiles as specified on Soil Erosion and Sediment Control Drawings. Dispose of excess excavation materials as specified.
   1. Excess excavated material shall be legally disposed of by removal from the project site.

3.8 EARTH FILL

A. Existing Ground Surface Preparation: Remove vegetation and topsoil as specified in Section 31 10 00 "Clearing". Proofroll exposed subgrade utilizing a heavily loaded dump truck or other pneumatic-tired vehicle of similar size and weight, in the presence of the Soils Engineer. Proofrolling shall not be performed during or following wet weather conditions.

B. Existing Subgrade Preparation: Remove unsuitable earth, upon completion of clearing and proofrolling operations, as specified. Continuously bench existing slopes exceeding four feet horizontal to one foot vertical. Bench sufficiently to accommodate earthmoving and compaction equipment. Select material, removed as a result of benching operations, may be used for fill and/or backfill as specified.
   1. Unpaved Areas: Scarify existing subgrade to six-inch depth and compact to 90 percent maximum dry density. Density test method: ASTM D 698.
   2. Paved Areas: Scarify existing subgrade to twelve-inch depth and compact to 98 percent maximum dry density, compact the top 18” to 100% maximum dry density. Density test method: ASTM D 698. Remove unsuitable earth, exhibiting excessive weaving during compaction operations, as specified.

C. Fill Placement: Do not place fill material on frozen or muddy subgrades.
   1. Unpaved Areas: Place fill material in loose lifts not exceeding eight-inches.

   2. Paved Areas: Place fill material in loose lifts not exceeding eight-inches.

D. Fill Compaction and Moisture Control: Obtain compaction with approved compaction equipment. Provide compaction equipment of proper size and in proper mechanical operating condition. All fill material shall be moisture conditioned to within two percent of optimum moisture content.
   1. Unpaved Areas: Compact each lift to 90 percent maximum dry density. Density test method: ASTM D 698.
   2. Paved Areas: Compact each lift to 95 percent maximum dry density, compact the top 18” to 100% maximum dry density. Density test method: ASTM D 698.

E. Control moisture during placement and compaction operations. Remove and replace or scarify and aerate excessively moist material until required moisture content is obtained. Moisten excessively dry material by applying measured amounts of water uniformly to fill material until required moisture content is obtained.

3.9 EARTH BACKFILL

A. General: Backfill excavations as promptly as work permits, but not until completion of inspection, testing and approval by the Soils Engineer.

B. Placement and Compaction: Do not place backfill on frozen or muddy subgrades.
   1. Unpaved Areas: Place backfill material in loose lifts not exceeding eight inches. Compact each lift to 90 percent maximum dry density. Density test method: ASTM D 698.

   2. Paved Areas: Place backfill material in loose lifts not exceeding eight inches. Compact each lift to 98 percent maximum dry density, compact the top 18” to 100% maximum dry density. Density test method: ASTM D 698.

   3. All material to be moisture conditioned to within two percent of optimum moisture content.

3.10 GRADING

A. General: Grade unpaved and paved areas to smooth and uniform surfaces and to prevent ponding of surface water.

1. Unpaved Areas: Areas to receive topsoil shall be graded to allow for installation of minimum 6 inches of topsoil. Refer to Section 32 93 05 "Topsoiling, Seeding and Sodding". Grade slopes exceeding four feet horizontal to one foot vertical, to smooth and uniformly rounded surfaces.
2. Paved Areas: Grade paved area subgrades to the lines, elevations and sections indicated or specified.

3.11 MAINTENANCE

A. Maintain all paved access roads in a clean and dust free condition during earthwork or subsequent construction operations. Clean trucks and equipment, removing mud and debris, prior to entering project site access roads and public right-of-way.

B. Maintain completed areas of project site free of trash and debris. Scarify, regrade and recompact subgrades damaged or disturbed by adverse weather, soil erosion, settlement and subsequent construction operations.

3.12 TESTING

A. The following tests will be conducted.
   1. Laboratory Density Tests:
      a. Test method: As specified.
      b. Test interval: One test per each 15,000 s.f., or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines, and 1 per each 5,000 s.f., etc, for areas done by hand-operated machines.
   2. 2. In-place Field Density Tests:
      a. Test method: ASTM D 1556-82 or D 2167.
      b. Density required: As specified.
      c. Test Interval: One test per 2,000 s.f., or fraction thereof, of compacted subgrade, or of each lift of fill or backfill compacted by other than hand-operated machines, and 1 per 1000 s.f., etc, for each lift of fill or backfill compacted by hand-operated machines.

B. Correct work not conforming to specified densities as directed by the Soils Engineer, at no increase to the Contract Sum.

- END OF SECTION 31 20 00 -

SECTION 31 20 05
BUILDING EARTHWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials, equipment and work required to perform building earthwork operations.

1.3 TESTING AND INSPECTIONS

A. Refer to Section 31 20 00 "Earthmoving".

B. All earthwork procedures shall be performed in the presence of the Soils Engineer. Give adequate (24 hours) notice when Soils Engineer's services are required. The Soils Engineer's duties will include, but not be limited to the following:

1. Observation, testing, and approval of subgrade for footings before placement of concrete.

2. Observation and approval of floor subgrade and fill placement before placement of underfloor granular base.

3. Testing of proposed import fill material and verification of correlation of the import material to laboratory test samples. All test results shall be forwarded to the seeding and sodding contractor.

4. Verification of removal of sediment from sediment control basins and testing of subgrade in basins prior to fill placement.

1.4 RELATED WORK

A. Refer to Section 31 10 00 "Clearing", Section 31 20 00 "Earthmoving".

1.5 CODES

A. Refer to Section 31 20 00 "Earthmoving".

1.6 STANDARDS

A. Refer to Section 31 20 00 "Earthmoving".

1.7 SUBMITTALS

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Product Samples: Submit samples of the borrow material and structural fill material to the Owners' Testing Agency. Sample size to be fifty pounds. Number of samples to be determined by the Owners' Testing Agency. The Contractor is required to get signed transmittals from the Owners' Testing Agency documenting delivery of samples to be submitted to the Construction Manager for Project Record.

C. For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

1.8 DEFINITIONS

A. Refer to Section 31 20 00 "Earthmoving".

1.9 PROJECT CONDITIONS

A. Refer to Section 31 20 00 "Earthmoving".

1.10 CONSTRUCTION SURVEYS

A. General: Retain the services of a locally registered land surveyor or professional engineer to provide horizontal and vertical alignment stakes required to perform building earthwork operations to subgrade elevations indicated or specified, and horizontal and vertical alignment stakes required to construct footings and foundations.

B. Earthwork Balance Conditions: Refer to Section 31 20 00 "Earthmoving".

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide aggregate manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

B. Fill Material: ASTM D 2487, Unified Soils Classification ML or more granular. Liquid limit not to exceed forty (40). Plasticity Index not to exceed twelve (12). Maximum particle size to be 2-1/2 inches. Free of debris, organic materials, waste materials and frozen materials. Obtain and transport fill materials from project site or borrow areas at no increase to contract sum.

C. Samples: Submit fill material samples for testing and approval to the Soils Engineer. Do not place fill until written approval is obtained. Sample approval will not relieve the contractor of the responsibility to have material placed conform to approved samples.

D. Porous Fill: ASTM C 33 Coarse Aggregate, size number 467 (1-1/2 inch to No. 4), blast furnace slag prohibited.

1. Size to be AASHTO M 43, size 57.

E. Backfill Material: Refer to Section 31 20 00 "Earthmoving".

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate building earthwork activities with the application of termite treatment. Refer to Section 31 31 16 "Termite Control".

3.2 PROTECTION AND RESTORATION

A. Refer to Section 31 20 00 "Earthmoving" and as noted. Provide support systems (e.g. sheeting, shoring, sheet piling, cribbing, etc.) at no increase to contract sum. Protect footing, foundation and slab subgrades, with insulating materials, to prevent frost penetration. Restore subgrades damaged from the lack of protection. Restoration work as directed by the Soils Engineer.

3.3 DEWATERING

A. Refer to Section 31 20 00 "Earthmoving" and as noted. Perform building earthwork operations to prevent water accumulations detrimental to stability of footing and foundation subgrades.

3.4 EXCAVATION

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Foundation Excavation: Excavate to footing and foundation elevations indicated or specified. Extend excavations horizontally beyond footings and foundations to permit formwork placement and removal, support system placement and removal, foundation drainage system installation, building utility installations, waterproofing and inspection. Do not place concrete until completion of inspections, testing and approval by the Soils Engineer. Trim and shape excavations by manual methods, prior to concrete placement.

C. Slab Excavation: Excavate to slab subgrade elevations indicated or specified. Excavate slab subgrades to smooth and even surfaces, free of voids and depressions. Prepare exposed subgrades as specified for paved areas, Section 31 20 00 "Earthmoving". Do not place concrete or porous fill until completion of inspection, testing and approval by the Soils Engineer. Inspection, testing and approval of subgrade shall be performed immediately prior to placement of porous fill and concrete.

D. Below Slab Utility Excavation: Refer to Section 33 10 00 "Utility Standards" and as noted.
   1. Trench width below and 12 inches above top of utility not to exceed 12-inch clearance on each side of utility.

3.5 OVER-EXCAVATION

A. Refer to Section 31 20 00 "Earthmoving" except as noted. Correct over-excavated areas as directed by the Soils Engineer or Owner's Representative.

3.6 UNSUITABLE EARTH

A. Refer to Section 31 20 00 "Earthmoving" except as noted. The Soils Engineer shall determine the least costly restoration method.

1. Restore excavated areas by lowering footings and foundations to bottom of excavated area.
2. Restore excavated area by backfilling with approved compacted fill material to design subgrade elevations.
3. Payment for unsuitable earth removal and associated restoration operations will be by Change Order.

3.7 EXCAVATED MATERIAL STORAGE

A. Refer to Section 31 20 00 "Earthmoving".

3.8 FILL

A. Refer to Section 31 20 00 "Earthmoving", except as noted.

B. Earth Fill: Prepare exposed subgrades as specified for paved areas, Section 31 20 00 "Earthmoving". Place fill material in loose lifts not exceeding eight inches and at moisture content within plus or minus two percentage points of optimum moisture content, and compact to 98 percent maximum dry density. Top 18 inches below foundations and slabs shall be compacted to 100 percent maximum dry density. Density test method: ASTM D 698.
   1. Compacted fill material shall extend at least ten feet beyond building lines for lateral support.

   2. Do not place concrete or porous fill until completion of inspection, testing and approval by the Soils Engineer. Inspection, testing and approval of subgrade shall be performed immediately prior to placement of porous fill and concrete.

C. Porous Fill: Upon approval of prepared subgrade, place porous fill in uniform lifts and compact to 70 percent relative density.

3.9 BACKFILL

A. Refer to Section 31 20 00 "Earthmoving". Place and compact backfill as specified for fill, except as noted.

B. Backfill excavations as promptly as work permits, but not until completion of formwork removal, foundation drainage system installation, building utility installations, waterproofing, termite treatment, trash and debris removal, support system removal, temporary and/or permanent wall bracing installation, and inspection and approval by the Soils Engineer.

C. Exercise care in the placement of backfill material adjacent to structure. Place backfill evenly and in a manner to prevent wedging action against the structure. Place backfill uniformly around the structure in lifts of equal elevation. Correct damage from improper backfilling operations, as directed by the Soils Engineer or Owner's Representative, at no increase to the Contract Sum.

D. Backfill placement operations to be tested and approved by the Soils Engineer.

3.10 TESTING

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Foundation Subgrade Testing: For each stratum of soil, on which foundations will be placed, conduct one test to verify required design bearing capacities. Conduct a minimum of one test beneath each wall. Subsequent verification and approval of each foundation subgrade may

be based on a visual comparison of each subgrade with related tested strata. Additional testing shall be conducted as required by the Soils Engineer.

3.11 MAINTENANCE

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Tests, inspections, and approvals specified will be conducted in accordance with applicable Division One Sections regarding "Testing Services".

- END OF SECTION 31 20 05 -

SECTION 31 31 16
TERMITE CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 RELATED WORK

A. Refer to Section 31 20 00"Earthmoving", and Division 3 "Concrete".

1.3 DESCRIPTION OF WORK

A. This section specifies application of Termite Control soil treatment prior to placement of concrete floor slabs, foundation walls or grade beams.

1.4 QUALITY ASSURANCE

A. Applicator's Qualifications: Applicators shall be registered or licensed where required by State or City jurisdictions.

1.5 WARRANTY

A. On final acceptance, furnish the Owner's Representative with a written guarantee, executed by the Applicator and the Contractor, stating application was made in accordance with this specification, and certifying that the applied soil termiticide treatment will prevent infestation of subterranean termites.

B. Guarantee effectiveness of treatment for not less than five years.

C. Guarantee to correct damage caused by termite infestations in treated areas, within the five-year guarantee period. If subterranean termite activity is discovered during the guarantee period, the Contractor will re-treat the soil and repair or replace damage caused by the termite infestation.

1.6 STANDARDS

A. United States Department of Agriculture Federal Insecticide, Fungicide and Rodenticide Act.

B. The formulation of all soil poisons, insecticides, fungicides, etc. shall be registered under the Act and shall be registered with the appropriate agency of the State of Maryland.

1.7 SUBMITTALS

A. Submit manufacturer's written mixing and application instructions.

B. Submit typewritten detailed description of termite treatment program to, and obtain approval from, the local jurisdiction prior to implementation.

C. Submit evidence of compliance with Federal and State regulations.

1.8 PROJECT CONDITIONS

A. Protect occupied portions of existing structures to remain from fumes and vapors from application of the termite treatment.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT SOLUTIONS

A. General: Use an emulsible, concentrated termiticide that dilutes with water, specially formulated to prevent termite infestation. Fuel oil will not be permitted as a dilutent. Use only soil treatment solutions that are not harmful to plants.

B. Provide a solution consisting one of the following chemical elements:
Premise, Bayer.
   1. Permathrin:
      a. Dragnet.
   2. Cypermethrine:
      a. Prevail FT, FMC Corp.
      b. Dermon, ICI Americas, Inc.
   3. Fenvalerate:
      a. Gold Coast Tribute, Du Pont
   4. Isofenphose:
      a. Pryfon, Mobay Corp.

C. Mixes: Dilute with water to concentration level recommended by the manufacturer. Follow manufacturer's written mixing instructions.

PART 3 - EXECUTION

3.1 INSPECTION

A. Verify that soil is in friable condition with moisture content low enough to permit absorption of toxicant solution. Remove any foreign matter which could decrease effectiveness of treatment.

B. Do not apply soil treatment until excavating, filling and grading operations are complete, except as otherwise required.

C. Do not apply soil treatment to frozen or excessively wet soils or during inclement weather.

3.2 APPLICATION

A. Apply soil treatment to areas beneath concrete floor slabs on grade or fill, suspended slab structures, at hollow masonry foundations and grade beams and along interior and exterior sides of foundation walls and grade beams.

B. Apply soil treatment at expansion joints, control joints and all areas where slabs will be penetrated.

C. Do not apply soil treatment solution until excavating.

3.3 RATE OF APPLICATION

A. Surface Preparation: Remove foreign matter which could decrease effectiveness of treatment on areas to be treated. Loosen, rake and level soil to be treated, except previously compacted areas under slabs and foundations. Toxicants may be applied before placement of compacted fill under slabs, if recommended by toxicant manufacturer.

B. Application Rates: Apply soil treatment solution as follows:

C. Under slab-on-grade structures, treat soil before concrete slabs are placed, using the following rates of application:

1. Apply 4 gallons of chemical solution per 10 linear feet to soil in critical area under slab, including entire inside perimeter inside of foundation walls, along both sides of interior partition walls, around plumbing pipes and electric conduit penetrating slab, and around interior column footers.

2. Apply one gallon of chemical solution per 10 square feet as an overall treatment under slab and attached slab areas where fill is soil or unwashed gravel. Apply one and one half gallons of chemical solution per 10 square feet to areas where fill is washed gravel or other coarse absorbent material.

3. Apply 4 gallons of chemical solution per 10 linear feet of trench, for each foot of depth from grade to footing, along outside edge of building. Dig a trench six inches to eight inches along outside of foundation to a depth of not less than 12 inches. Punch holes to top of footing at not more than 12 inches on center and apply chemical solution. Mix chemical solution with the soil as it is being replaced in trench.

D. Under crawl-space and basement structures, treat soil along exterior and interior walls of foundations with shallow footings as specified above for exterior of slab-on-grade structures.

E. At hollow masonry foundations or grade beams, treat voids at rate of 2 gallons per 10 linear feet, poured directly into the hollow spaces.

F. At expansion joints, control joints, and areas where slabs will be penetrated, apply at a rate of 4 gallons per 10 linear feet of penetration.

G. Post signs in areas of application to warn workers that soil termiticide treatment has been applied. Remove signs when areas are covered by other construction.

H. Re-apply soil treatment solution to areas disturbed by subsequent excavation, landscape grading, or other construction activities following application.

- END OF SECTION 31 31 16 -

SECTION 31 50 00
EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Work of this section includes sheeting and shoring and bracing.

1.2 RELATED SECTIONS

A. Section 31 10 00: Clearing

B. Section 31 20 00: Earthmoving

1.3 SYSTEM DESCRIPTION DESIGN REQUIREMENTS

A. Shoring systems shall be designed to safely and adequately prevent collapse of adjacent materials and permit construction of Work to arrangement shown on Contract Documents.

B. Secure approvals, including those of local governmental agencies having jurisdiction.

C. Analyze site conditions. Make supplemental investigations as needed for proper design of shoring.

1.4 QUALITY ASSURANCE SUBMITTALS FOR DESIGN DATA

A. Prepare and submit design drawings and calculations showing analysis of work to be performed, including horizontal support for shoring.

B. Drawings shall include methods, equipment and work procedures.

1.5 QUALITY ASSURANCE

A. Qualifications
   1. Bracing and shoring drawings shall be prepared by a registered professional engineer, licensed to practice in the State of Maryland. Drawings and calculations shall bear seal of Professional Engineer registered in the State of Maryland.

   2. Personnel performing installation shall be trained or qualified in techniques and procedures of shoring installation with a minimum of three (3) years successful experience in such installation.

   3. Installation shall be performed under supervision of a Professional Engineer registered in the State of Maryland, experienced in this type of work.

B. Regulatory Requirements: Conform to requirements of Occupational Safety and Health Administration (OSHA) as well as measures accepted as standards of industry.

C. Certifications: Upon completion of shoring, submit a letter signed and sealed by design engineer stating that, to best of his or her knowledge, systems were constructed in compliance with design drawings and calculations.

1.6 LEED Submittals

A. Product data for Credit MR 4.: For products having recycled content, documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

B. Product data for Credit MR 5: For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be selected and furnished to perform in compliance with design criteria.

B. Structural Steel Shapes and Plates: ASTM A 36 or ASTM A 572. Steel shall be of American manufacturer, new and free from defects in strength, durability, appearance and function.
   1. Recycled Content: Provide steel with minimum 90 percent total recycled content, including at least 60 percent post-consumer recycled content.

   2. Regional Materials: Provide steel manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Verification of Conditions: Prior to commencing work of this Section, check and verify governing dimensions and elevations, including field measurements of existing or adjoining work on which this work is dependent to assure proper fit and clearances between new and existing structures.

3.2 PREPARATION

A. Protection
   1. Protect and support water, sewer, gas, and other pipes and electrical conduits encountered and immediately notify persons, companies or governmental agencies, granting them ample opportunity to take such additional precautions as they may deem necessary.

   2. Cut and cap street connections encountered in excavating along curb lines in compliance with local jurisdiction requirements. Mark locations of capped utilities so they may be subsequently located and reconnected as needed.

   3. Damage to adjacent properties, streets, sidewalks and utilities caused by work under this Section shall be repaired, restored to original condition, or replaced at no additional expense to Owner.

B. Coordination
   1. Prepare a photographic or video survey of existing crack conditions in adjacent facilities and other conditions of structures prior to commencing work.

   2. Maintain free flow of pedestrian and vehicular traffic to and from adjacent properties at levels existing prior to start of work and as described in Section 31 10 00 “Clearing”.

3. Interior bracing shall be arranged to offer no interference with formwork for new construction.

4. Provide sufficient quantity of materials on hand at all times for protection of Work and for use in event of emergency.

5. Setting of formwork, reinforcing and placement of concrete shall be in compliance with requirements described in other related Sections of this Project Manual.
6. Provide pumps and other equipment as necessary to dewater excavations for shoring operations.

C. Sheeting
1. Provide sheeting of proper lengths and section needed, and anchor or brace to resist earth and hydrostatic pressures and superimposed loads from adjacent structures and/or construction equipment.

2. Install sheeting plumb and true, to lines and locations as indicated on design submittal drawings. Sheeting shall be used to form concrete walls and shall be located and driven to ensure that no part of sheeting is within outline of permanent construction.

3. Sheeting retaining earth on which support and stability of existing structures is dependent shall be left in place at completion of Work.

D. Shoring
1. Locate shoring at distances away from new construction sufficient to allow working room and observation of construction.

2. Shoring shall be set clear of permanent footings, walls and other structural features.

3. Shoring shall be installed to retain earth under surcharges, including such loads as weight of construction materials and equipment, vibration, snow, rainwater, water absorption by soils, and temporary construction.

4. Extend shoring as high as necessary to allow for construction of foundation walls and for berming to divert water run-off. Depth of shoring shall be as deep as necessary to brace excavation to ultimate depth.

5. Shoring supporting formwork may not be left in place upon written approval by the Owner's Representative.

3.3 RESTORATION

A. Remove temporary protective installations upon completion of shoring operations.

B. Repair damage to structures caused by shoring operations and restore surfaces to original or better condition.

3.4 CLEANING

A. Remove debris and excess earth resulting from shoring operations as it accumulates. Do not store debris on site or permit debris to be scattered over site.

- END OF SECTION 31 50 00 -

SECTION 32 12 16
HOT-MIXED ASPHALT PAVEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to construct new asphalt pavement, asphalt curbing, asphalt walks and overlay existing asphalt pavement.

1.3 RELATED WORK

A. Refer to Section 31 10 00 "Clearing", Section 31 20 00 "Earthmoving", and Section 32 13 15 "Concrete Curbing".

1.4 STANDARDS

A. Maryland Department of Transportation State Highway Administration, current "Standard Specifications for Construction and Materials".

B. Frederick County Department of Transportation current "Design Standards".

1.5 SUBMITTALS

A. Products:
   1. Submit asphalt plant mix formula, for each course specified. Mix formula to include percentage of aggregate passing each sieve size, percentage of bituminous material added to aggregate and mix temperature.

   2. Submit certificates, signed by producer or manufacturer and contractor, stating that base course material and asphalt comply with this specification.

   3. Submit results of testing specified for review by the Architect, Owner's Representative and required jurisdictional inspectors.

   4. For products having recycled content, documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

5. For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

1.6 PRODUCT DELIVERY AND STORAGE

A. Asphalt mixtures: Delivery temperature not to exceed 25 degrees Fahrenheit below plant mix temperature.

1.7 PROJECT CONDITIONS

A. Existing Asphalt Pavements: Verify existing pavement conditions (e.g. deteriorated surface, joints, etc.) during prebid inspection.

B. Traffic: Maintain vehicular traffic during pavement construction operations.

C. Limitations: Do not proceed with pavement construction until underground utility construction is complete. Do not proceed with asphalt placement operations until adjacent or adjoining Portland cement concrete curb construction is complete. Do not place bituminous materials when ambient air temperature is below 40 degrees Fahrenheit or air temperature has been below 35 degrees Fahrenheit for 12 or more consecutive hours. Do not place materials from 15 November to 1 March without written authorization from the Architect.

D. Construction Surveys: Retain the services of a locally registered land surveyor or professional engineer to provide combined horizontal and vertical alignment stakes for road base construction.
   1. Paved area base alignment stake horizontal interval: 50 foot maximum stations at centerline and both edges to finished base elevations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide products manufactured and of raw materials extracted/recovered within a 500-mile radius of the Project Site.

B. Subbase Course: SHA Graded Aggregate Subbase: Section 901.01.

C. Asphalt Base (Binder) Course: Shall be Bituminous Concrete intermediate band, SuperPave, 19.0mm PG 64-22 Band per Division 5000 and Section 904A of the Reference Specification. Compacted thickness as noted on the plans.

D. Tack Coat: SHA cut-back asphalt: Section 904.04, M 81 or M 82.

E. Overlay Binder Coat: Asphalt cement: AASHTO M 20, penetration grade 80-100.

F. Overlay Protective Membrane: "Petromat" protective membrane manufactured by Phillips Fiber Corporation, a subsidiary of Phillips Petroleum Company, Greenville, South Carolina.
   1. Option: "AmoPave" protective membrane manufactured by Amoco Fabrics Company, Atlanta, Georgia.

G. Overlay Protective Membrane Strips: "PavePrep" fiber reinforced mastic strips, manufactured by The PavePrep Corporation, Westfield, New Jersey.

H. Asphalt Surface Course: Shall be Bituminous Concrete surface band, SuperPave, 9.5mm PG 64-22 Band per Division 5000 and Section 904A of the Reference Specification. Compacted thickness as noted on the plans.

I. Asphalt Surface Course for Athletic Courts and Paved Play Areas: Shall be Bituminous Concrete surface band, SuperPave, 4.75mm PG 64-22 Band per Division 5000 and Section 904A of the Reference Specification. Compacted thickness as noted on the plans.

J. Joint Sealant: MDOT-SHA Section 911.01.

K. Provide minimum 25 percent recycled asphalt paving (RAP).

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION

A. Asphalt Pavement: Protect improvements and facilities during tack coat and overlay binder coat applications to prevent overspray damage. Protect completed surface from damage. Do not permit heavy equipment or rollers on completed surface. Do not permit vehicular traffic on surface for 24 hours after completion. Restore damaged pavement as directed by the Owner's Representative or the Architect, at no increase to contract sum.

3.2 SUBGRADE PREPARATION

A. Paved Areas: Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Verify subgrade compaction and elevations and correct discrepancies before proceeding with base construction. Verify utility casting elevations and reset or adjust to meet flush with finished pavement surface. Do not place the base material/subbase material on frozen or muddy subgrade.

3.3 SUBBASE COURSE

A. Place subbase course material on prepared subgrade in one uniform layer to depth required to produce compacted thickness indicated. Shape material, to sections and elevations indicated with blade grader and compact with pneumatic tired rollers to 98 percent maximum dry density. Control moisture content of the base course material to within 2 percent of optimum during compaction operations. Compaction Standard: ASTM D 698. Proof roll subbase course with 10 ton tandem steel wheel roller and correct irregularities.

3.4 ASPHALT BASE COURSE

A. Subbase Course Surface Preparation: Apply tack coat material to previously placed asphalt base course, existing pavement, curbing, utility castings and any structure abutting or projecting into paved area.

B. Base Course Placement: Place asphalt in layers not exceeding four inches in compacted depth to total depth required to produce compacted thickness indicated. Place material with mechanical self-powered pavers capable of maintaining required line and grade. Place material by approved manual methods in areas inaccessible to self-powered pavers. The temperature of the material shall be not less than 225 degrees Fahrenheit at the time of placement.

C. Base Course Compaction: Compaction operations shall begin immediately following placement of the base course material, and shall consist of breakdown, intermediate and finish rolling. Material shall be compacted to in-place density of 92 to 97 percent of theoretical maximum density. In-place compaction shall be completed before the material cools below 185 degrees Fahrenheit. Use self-powered tandem steel wheel rollers. Use power driven trench rollers in areas inaccessible to self-powered equipment. Begin rolling longitudinally at low side or edge and proceed toward high side or crown. Overlap successive roller trips one half-roller width. Do not terminate alternate roller trips at the same location. Continue finish rolling until 98 percent to 102 percent theoretical maximum density is obtained and all roller marks are eliminated. Density test method: AASHTO T 230.

3.5 ASPHALT SURFACE COURSE AND OVERLAY

A. General: Provide overlay protective membrane treatment where indicated. Provide overlay protective membrane strips over all long, running cracks or pavement joints except in areas where overlay protective membrane is already indicated.

B. Asphalt Base Course Surface Preparation: Remove loose material from surface before applying tack coat. Apply tack coat material uniformly to surface at a rate of 0.10 gallon per square yard. Allow tack coat to cure as long as required to properly set but not less than 12 hours.

C. Existing Asphalt Pavement Preparation: Clean and dry pavement, with compressed air, removing debris, dust, foreign materials and moisture.

1. Obtain pavement preparation approval, from the Architect prior to overlay binder coat application. Apply overlay binder coat material uniformly to prepared asphalt surface. Apply at a rate of 0.25 gallon per square yard. For long running cracks or joints in existing pavement surface where overlay protective membrane strips will be used, apply overlay binder coat material to a width of approximately two feet so as to span existing cracks or joints. Adjust application rate, based on existing pavement relative porosity, at no increase to contract sum. Apply overlay binder coat material at 300 degrees Fahrenheit minimum to 350 degrees Fahrenheit maximum.

2. Lay down overlay protective membrane, on cured overlay binder coat, in accordance with manufacturer's installation instructions and as noted. Transverse joint overlap to be 12 inches, "shingled" in the direction of paving to prevent edge pick-up by the pavers. Longitudinal joint overlap to be six inches. Cut and piece membrane to fit irregular shaped areas (e.g. access road intersections, curb returns, etc.). Obtain pavement preparation approval from the Owner's Representative or the Architect prior to tack coat application.

3. Lay down overlay protective membrane strips on cured overlay binder coat, in accordance with manufacturer's installation instructions and as noted. Unroll overlay protective membrane strips, aligned with pavement joints, and seat in tacky overlay binder coat material by brooming, so as to span existing pavement joints. Blot excess overlay binder coat materials on the edges of the membrane strips with sand blanket. Cut and piece membrane to fit irregular shaped areas (e.g. access road intersections, curb returns, etc.). Obtain pavement preparation approval from the Owner's Representative or the Architect prior to tack coat application.

4. Apply tack coat material uniformly to prepared asphalt surface. Apply at rate of minimum of 0.05 gallons per square yard and a maximum of 0.15 gallons per square yard. Tack coat to cure as long as required to properly set, but not less than 12 hours.

5. Prepare existing asphalt pavement, as indicated and specified, at no increase to contract sum.

D. Surface Course and Overlay Placement: Place asphalt, in one uniform layer, to depth required to produce the compacted thickness indicated. Place with mechanical self-powered pavers capable of maintaining required line and grade. Place and spread asphalt by approved manual methods in areas inaccessible to self-powered pavers. The temperature of the material shall be not less than 225 degrees Fahrenheit at the time of placement.

E. Surface Course and Overlay Compaction: Compaction operations shall begin immediately following placement of the surface course material, and shall consist of joint, breakdown, intermediate and finish rolling. In-place compaction shall be completed before the material cools below 185 degrees Fahrenheit. Use power driven trench rollers in areas inaccessible to self-powered rollers. Begin rolling longitudinally at low side or edge and proceed toward high

side or crown. Overlap successive roller trips, one-half roller width. Do not terminate alternate trips at same point. Continue finish rolling until 98 percent to 102 percent theoretical maximum density is obtained and all roller marks are eliminated. Density test method: AASHTO T 230.

JOINT SEALING

F. Completely seal and fill joints along existing and new pavement and curbing interface with joint sealant.

3.6 TESTING

A. General: Correct work not conforming to specified tolerances as directed by the Owner's Representative or the Architect, at no increase to the contract sum.

B. Thickness Tests: Conduct subbase, base and surface course thickness tests and provide test area restoration upon completion. Tolerance not less than one-half inch from compacted thickness indicated. Test locations are random and to be determined by the Owner's Representative or the Architect. Regardless of paved area size, at least one test shall be performed for each newly paved area.

C. Smoothness Tests: Conduct surface course smoothness tests. Tolerance not to exceed one- eighth inch between any two surface contacts on 10-foot straightedge. Test locations are random and to be determined by the Owner's Representative or the Architect. Regardless of paved area size, at least one test shall be performed for each newly paved area.

D. Laboratory Density Tests: Conduct subgrade, subbase and base course laboratory density tests. Density testing shall be performed by individuals certified to perform asphalt testing. Test method: ASTM D 1557. Test interval to be determined by the Owner's Representative or the Architect, but no less than one test for each newly paved area and/or one test per 1000 feet of roadway shall be performed.
   1. Provide test area restoration.

E. Field Density Tests: Conduct subgrade, subbase and base course in-place field density tests. Density testing shall be performed by individuals certified to perform asphalt testing. Test method: ASTM D 1556 or D 2167. Test locations are random and to be determined by the Owner's Representative or the Architect, but no less than one test for each newly paved area and/or one test per 1000 feet of roadway shall be performed.
   1. Provide test area restoration.

3.7 CLEANING

A. Clean improvements and facilities damaged by tack coat overspray as directed by the Owner's Representative or the Architect.

- END OF SECTION 32 12 16 -

SECTION 32 12 20
ROAD AND PARKING ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to apply, install and construct miscellaneous road and parking accessories.

1.3 RELATED WORK

A. Refer to Section 31 20 00 "Earthmoving", and Section 32 13 15 "Concrete Curbing".

1.4 STANDARDS

A. Maryland Department of Transportation State Highway Administration's current "Standard Specifications for Construction Materials".

B. "Manual on uniform Traffic Control Devices for Streets and Highways" ANSI D6.1-1971.

1.5 SUBMITTALS

A. Products:
   1. Submit manufacturer's specifications and application instructions for pavement marking paint.
   2. Submit manufacturer's descriptive literature for road and parking area signs.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver paint to project site in original unopened containers bearing manufacturer's label.

B. Store paint in tightly covered containers.

1.7 PROJECT CONDITIONS

A. Maintain vehicular and pedestrian traffic during pavement marking operations. Do not apply paint when ambient air temperature is below 50 degrees Fahrenheit, relative humidity exceeds 85%, wind exceeds 20 miles per hour or pavement surface temperature is below 50 degrees Fahrenheit.

B. Contractor shall notify Fire Marshal within 48 hours of completion of curbing and pavement construction to schedule site inspection for purposes of designating locations of curb marking. Curbs at fire lanes shall be painted yellow, unless noted otherwise by the Fire Marshal.

C. Curbs and line stripes at handicapped parking spaces shall be painted yellow.

D. All other on-site striping shall be white.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pavement Marking: AASHTO M 248, type I, non-reflective paint, colors as noted. Materials used in the Public Right-of-Way shall be Type B, Class I, Thermoplastic alkyd. Materials used in the Public Right-of-Way shall be approved by Frederick County Department of Transportation, Traffic Engineering prior to installation. Colors shall be:
   1. Standard Parking Spaces: White
   2. Bus Stacking Spaces: White
   3. Handicapped Parking Spaces Yellow
   4. Traffic Lanes: Yellow

B. Curb Marking: AASHTO M 248, type I, reflective yellow paint.

C. Road and Parking Area Signs:
   1. Handicapped Parking Area and Fire Lane Signs: In accordance with Frederick County Department of Transportation standards, and the MUTCD.
   2. Stop Signs shall be 30" by 30" signs.

D. Traffic Control Signs:
   1. Traffic control signs in accordance with Frederick County Department of Transportation's standards, the MUTCD, and as indicated.

E. Sign Posts: Galvanized steel channel with 5/16 by two inch steel nuts and bolts and galvanized steel washers.

PART 3 - EXECUTION

3.1 PAVEMENT MARKING

A. Surface Preparation: Clean pavement surfaces, removing grease, oil, mud and foreign materials.

B. Preparation for New Pavement Markings: Layout markings to dimensions and line widths indicated and specified. Bituminous concrete pavement to cool and set five calendar days prior to paint application. Do not apply marking materials to wet or damp pavement surfaces. Do not apply marking materials until pavement marking removal paint has set and hardened. Surfaces to set an additional eight hours after appearing dry.

C. Application: Thermoplastic pavement marking materials shall be applied to the pavement at a minimum temperature of 400 degrees Fahrenheit. Apply paint to width and length of pavement marking lines indicated, and as noted. Apply paint with spray equipment and/or conventional traffic line striping equipment, and in accordance with paint manufacturer's recommendations, to produce markings parallel and with sharp line edges, uniform in cross section and with line widths as indicated or specified. Minimum application rate to be 100 feet per gallon.
   1. Layout and apply paint for universal handicapped space symbols in accordance with standard practice and as directed by the Architect or the Owner's Representative.

D. Protection and Restoration: Protect completed paint marking from damage. Do not permit vehicular or pedestrian traffic on completed marking until paint has set and hardened. Restore damaged paint marking as directed by the Architect.

3.2 CURB MARKING

A. Locations:
   1. Fire Marshal will tour site after completion of curbing and pavement construction. During tour Fire Marshal will indicate locations where curb marking is to be applied. Contractor shall apply markings at no increase to contract sum.

B. Application: Allow concrete curbing to cure 14 calendar days prior to paint application. Clean curb surfaces removing grease, oil, mud and foreign material. Do not apply paint to wet or damp curb surfaces. Apply paint to face and top of curbing by manual brush methods or with spray equipment.

3.3 ROAD AND PARKING AREA SIGNS

A. Sign Locations: Locations of various sign types shall be as indicated on Construction Drawings and as directed by the Owner and the Architect. Contractor shall provide and install indicated and selected signs at no increase to Contract Sum.

B. Post Installation: Excavate post footing to 12 inch diameter and 30 inch depth. Place and consolidate concrete in footing excavation. Install post and assembled sign in concrete plumb to 1/4 inch in 10 feet and 24 inch depth. Provide bracing to prevent movement. Slope concrete surface one inch with outside edges flush with finished grade and trowel to smooth finish. Contractor shall allow concrete footings to cure a minimum of 14 calendar days before removing bracing.

- END OF SECTION 32 12 20 -

SECTION 32 13 13
CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to construct Portland cement concrete walks.

1.3 RELATED WORK:

A. Refer to Section 31 20 00 "Earthmoving", and Section 32 13 15 "Concrete Curbing".

1.4 STANDARDS:

A. Maryland Department of Transportation State Highway Administration's current "Standard Specifications for Construction and Materials".

B. Frederick County, Department of Transportation's current "Design Standards".

1.5 SUBMITTALS:

A. The contractor shall provide a sample of eight linear feet of typical concrete walk, with a control joint, for approval by the Owner's Representative. No additional concrete walk may be constructed until the sample is inspected and approved.

B. For products having recycled content, documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

C. For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

1.6 PROJECT CONDITIONS

A. Traffic: Maintain pedestrian traffic during walk construction operations.

B. Limitations:
1. Underground Utilities: Do not proceed with concrete construction until underground utility construction is complete.

2. Curbing: Do not proceed with concrete walk construction until adjacent or adjoining curb construction is complete.

3. Environmental: Refer to Section 33 10 00 "Utility Standards".

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content:
   1. Provide recycled concrete (RC-6) subbase and fill material, except under building slab.

   2. Provide minimum 25 percent recycled content in Portland Cement replacement with Engineer's approval.

   3. Provide steel bars with minimum 90 percent recycled content with at least 60 percent postconsumer.

B. Provide aggregate and steel reinforcing bars manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

C. Gravel Base: ASTM C 33 coarse aggregate, size number 6 (1" to No. 4).
   1. Contractor's Option: MDOT-SHA Coarse Aggregate No. 57 Stone.

D. Concrete: Class "A" Portland cement concrete, Section 33 10 00 "Utility Standards".
   1. Maximum 50% GGBF slag replacement for Portland cement, per MDOT-SHA Specification 902.06.05

E. Joint Materials: Expansion and Isolation Joints: ASTM D 994, bituminous preformed joint filler, 1/2 inch thick.

F. Forms: Steel or wood for straight or tangent walks. Non-rented wood materials shall be FSC-certified sustainably harvested.

G. Curing Materials: Burlap Mats: AASHTO M182, Class 1.

H. Miscellaneous Products:
   1. Form Release Compound: Non-staining, zero-VOC, 100% biodegradable made from plant-based oils and approved by the Architect.

   2. Cement Mortar: Section 33 10 00 "Utility Standards".

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION:

A. Concrete: Protect completed concrete from damage. Restore damaged concrete as directed by the Owner's Representative or the Architect.

3.2 SUBGRADE PREPARATION:

A. Paved Areas: Section 31 20 00 "Earthmoving" and as noted. Verify subgrade elevations and compaction and correct discrepancies before proceeding with construction. Verify utility casting elevations and reset or adjust to meet flush with finished concrete surface. Remove loose material from subgrade prior to gravel base placement.

3.3 GRAVEL BASE PLACEMENT:

A. Place and compact gravel base on prepared subgrade to depth indicated. Remove debris from surface of gravel base prior to placement of concrete. Do not place gravel base material on frozen or muddy subgrade.

3.4 FORMS

A. Clean and coat forms with form release compound, prior to use. Install forms to lines, grades and elevations indicated or as specified. Brace forms to prevent movement during concrete placement.

3.5 EXPANSION JOINTS

A. Install expansion joints at maximum 25-foot intervals or as indicated. Install expansion joints, adjacent to curbing, opposite curbing joints and as indicated. Place expansion joints perpendicular to concrete surface and with top edge 1/4 inch below concrete surface.

3.6 ISOLATION JOINTS

A. Install isolation joints where concrete abuts buildings, existing walk sections, utility structures and concrete curb. Place isolation joints with top edge 1/4 inch below concrete surface.

3.7 CONTRACTION JOINTS (SCORE LINES)

A. Provide contraction joints at five-foot intervals or as indicated. Form contraction joints with 3/4 inch jointing tool.

3.8 CONCRETE PLACEMENT

A. Sample Approval: No concrete walks may be constructed until the sample section has been inspected and approved by the Owner's Representative.

B. General: Place concrete in forms in one uniform layer. Consolidate concrete by tamping, spading or vibrating to prevent honeycombing. Place and consolidate concrete carefully to prevent dislocation of joint materials.

3.9 FINISHING

A. General: Draw a fine hair broom across concrete surface. Where longitudinal grade exceeds five percent, use a coarse texture finish by drawing a stiff bristle broom across concrete surface.
B. Handicapped Ramps: Handicapped ramps shall have exposed aggregate (or other approved detectable) surface.

3.10 CURING

A. Mat Method: Moisten mats thoroughly with water before placing on exposed concrete surfaces and overlap six inches. Cover mats with polyethylene sheeting and maintain mats in continuously moist condition for seven calendar days. Repair or replace damaged mats.

3.10 TESTING

A. General: Correct work not conforming to tolerances as directed by the Owner's Representative or the Architect, at no increase to the contract sum.

B. Walk Horizontal Alignment Test: Tolerance not to exceed 1/2 inch between any two contacts on 10-foot straightedge, except along horizontal curves. Test locations random and deter-

mined by the Owner's Representative or the Architect. Test observation by the Owner's Representative or the Architect.

C. Walk Surface Smoothness Test: Tolerance not to exceed 3/8 inch between any two surface contacts on 10-foot straightedge. Test locations random and determined by the Owner's Representative or the Architect. Test observation by the Owner's Representative or the Architect.

- END OF SECTION 32 13 13 -
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SECTION 32 13 15
CONCRETE CURBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to construct Portland cement concrete curbing.

1.3 RELATED WORK

A. Refer to Section 31 20 00 "Earthmoving", and Section 32 13 13 "Concrete Paving".

1.4 STANDARDS

A. Maryland Department of Transportation State Highway Administration's current "Standard Specifications for Construction and Materials".

B. Frederick County, Department of Transportation's current "Design Standards".

1.5 SUBMITTALS

A. Submit cut sheets for construction of curb in the public right-of-way to and obtain approval from the governing jurisdiction and the Architect prior to curb construction.

B. The contractor shall provide a sample of eight linear feet of typical concrete curb-and-gutter, with a control joint, for approval by the Owner's Representative. No additional concrete curbing may be constructed until the sample is inspected and approved.

C. LEED Submittals
   1. Product data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

   2. Product data for Credit MR 5: For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

1.6 PROJECT CONDITIONS:

A. Traffic: Maintain vehicular and pedestrian traffic during curb construction operations.

B. Limitations:
   1. Environmental: Refer to Section 33 10 00 "Utility Standards".

2. Underground Utilities: Refer to Section 32 13 13 "Concrete Paving".

1.7 CONSTRUCTION SURVEYS

A. Retain the services of a locally registered land surveyor or professional engineer to provide combined horizontal and vertical alignment stakes for curb construction within public right of way. Horizontal stake interval 25 feet maximum.

B. Provide combined horizontal and vertical alignment stakes for project site curb construction. Horizontal stake interval 25 feet maximum.

PART 2 - PRODUCTS

2.1 MATERIALS:

B. Concrete: Class 'A' Portland cement concrete, Section 33 10 00 "Utility Standards"

C. Joint Materials: Expansion and isolation joints: ASTM D 994, bituminous preformed joint filler, 1/2 inch thick.

D. Forms: For straight or tangent curbing use steel or wood. For curved curbing use flexible spring steel or laminated wood.

E. Curing Material: Refer to Section 32 13 13 "Concrete Paving".

F. Stone Base: SHA GA-Subbase, as indicated.

G. LEED Submittals
1. Recycled Content: Provide minimum 25 percent recycled content in Portland cement replacement.

2. Regional Materials: Provide aggregate manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION:

A. Refer to Section 32 13 13 "Concrete Paving".

3.2 SUBGRADE PREPARATION

A. Refer to Section 32 13 13 "Concrete Paving".

3.3 FORMS

A. Refer to Section 32 13 13 "Concrete Paving", and as noted.

B. Form curbing to standards indicated and specified.

3.4 EXPANSION JOINTS

A. Refer to Section 32 13 13 "Concrete Paving" and as noted.

B. Install expansion joints at maximum 30-foot intervals or as indicated. Place expansion joints perpendicular to surface and curbing face. Place combination curb and gutter expansion joints, with top edge one-half inch below gutter surface.

3.5 ISOLATION JOINTS

A. Refer to Section 32 13 13 "Concrete Paving".

3.6 CONTRACTION JOINTS:

A. Refer to Section 32 13 13 "Concrete Paving" and as noted.

B. Provide contraction joints, perpendicular to surface and face of curbing, at 10 foot intervals. Place contraction joints at all points where curved and tangent sections of curbing meet. Place contraction joints with removable form spreader places. Contractor's option: Score or saw joints to 1-1/4 inch depth.

3.7 CONCRETE PLACEMENT

A. Refer to Section 32 13 13 "Concrete Paving".

3.8 FINISHING

A. Strike off top surfaces of curbing to top of forms and to smooth and uniform texture. Strip curb face forms when concrete takes initial set. Trowel curb face to smooth and uniform texture. Finish top surfaces and curb face to fine texture by drawing a soft bristle brush longitudinally along curb. Finish edges of curbing with edging tool having a radius as indicated. Maintain forms, except curb face forms, in place 12 hours after concrete placement. Correct defects (e.g. holes, honeycomb areas, broken edges, etc.) upon removal of remaining forms, with cement mortar. Finish contraction joints with 1/4-inch radius edging tool. Finish curbing joints to clean and true edges. Maintain curbing surfaces moist during finishing operations.

B. Curing: Refer to Section 32 13 13 "Concrete Paving".

- END OF SECTION 32 13 15 -

SECTION 32 30 00
SITE FURNISHINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following site and street furnishings:

1. Bike Racks
2. Benches.
3. Trash receptacles.

B. Related Sections include the following:

1. Section 31 20 00 "Earthmoving" for excavation for installation of concrete footings.
2. Division 3 “Concrete" for formed voids in concrete footings.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, finishes, field-assembly requirements, and installation details.

1. Submit location of product manufacture

B. Samples for Verification: Provide a color chart for selection, actual samples are not necessary.

C. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

D. Material Certificates: For site furnishings, signed by manufacturers.

1. Recycled plastic.

E. Maintenance Data: For site furnishings to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of site and street furnishings through one source from a single manufacturer.

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Bench Replacement Slats: Not less than two full-size units for each size indicated.
2. Trash Receptacle Inner Containers: 1 full-size unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Products: Subject to compliance with requirements, provide the following products by or a comparable product by another manufacturer approved by Architect prior to bid, giving preference to products manufactured within a 500-mile radius of the Project Site.

1. Bike Racks: Victor Stanley, Inc; Model BRWS-101 (in-ground mounted, with powder coat over a galvanized finish (color selected by architect))
2. Bench: Victor Stanley, Inc.; Homestead Series Model 32.
3. Trash Receptacles: Victor Stanley, Inc.; Model ES-242.

2.2 MATERIALS

A. Steel: Free from surface blemishes and complying with the following:

1. Plates, Shapes, and Bars: ASTM A 36/A 36M.
2. Steel Pipe: Standard-weight steel pipe complying with ASTM A 53, or electric-resistance-welded pipe complying with ASTM A 135.
3. Tubing: Cold-formed steel tubing complying with ASTM A 500.
4. Sheet: Commercial steel sheet complying with ASTM A 569/A 569M.

B. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
1. Recycled Polyethylene: Fabricated from not less than 96 percent recycled, purified, fractional-melt plastic resin for not less than 90 percent recycled post-consumer waste by weight content HDPE.

C. Anchors, Fasteners, Fittings, and Hardware: Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality; tamperproof, vandal and theft resistant; concealed, recessed, and capped or plugged. Provide as required for site furnishings' assembly, mounting, and secure attachment.

D. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

2.3 BIKE RACKS

A. Frame: Steel.

B. Table Height: As indicated by basis-of-design product.

C. Overall Width: As indicated by basis-of-design product.

D. Overall Depth: As indicated by basis-of-design product.

E. Weight: As indicated by basis-of-design product.

F. Color: As selected by Architect from manufacturer's full range.

2.4 BENCHES:

A. Frame: Steel.

B. Seat and Back: Plastic; formed from evenly spaced parallel slats.

C. Arms: None.

D. Seat Height: As indicated by basis-of-design product.

E. Overall Width: 6 feet.

F. Overall Depth: As indicated by basis-of-design product.

G. Weight: As indicated by basis-of-design product.

H. Seat Surface Shape: As indicated by basis-of-design product.

I. HDPE Color: As selected by Architect from manufacturer's full range.

2.5 TRASH RECEPTACLES

A. Materials: 3/8” x 1” vertical solid steel bar; 1/4” x 2-1/2” horizontal solid steel bands; 3/8” x 3” steel support bars; 5/8” solid steel top ring; 36 gallon capacity high density plastic liner; leveling feet with a 3/8” diameter threaded steel shaft

B. Lids and Tops: Formed lid attached to the frame with two vinyl-coated steel aircraft cables.

C. Style: As indicated by basis-of-design product.

D. Weight: As indicated by basis-of-design product.

E. Liners: High-density plastic liner.

F. Capacity: Not less than 24 gal.

G. Installation Method: Anchored to cast in place concrete.

2.6 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Steel and Iron Components: Galvanized, galvanized and color coated, or color coated. Bare metal steel or iron components are not permitted.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; smooth all surfaces, free from burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

F. Factory Assembly: Assemble components in the factory to the greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.7 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.8 STEEL AND GALVANIZED STEEL FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester-TGIC, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance.

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

3.2 INSTALLATION, GENERAL

A. Comply with manufacturer's written installation instructions, unless more stringent requirements are indicated. Complete field assembly of site and street furnishings, where required.

B. Unless otherwise indicated, install site and street furnishings after landscaping and paving have been completed.

C. Install site and street furnishings level, plumb, true, and securely anchored or positioned at locations indicated on Drawings.

3.3 CLEANING

A. After completing site and street furnishing installation, inspect components. Remove spots, dirt, and debris. Repair damaged finishes to match original finish or replace component.

- **END OF SECTION 32 30 00 -**

SECTION 32 30 10
MODULAR PLAYGROUND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General Conditions and Supplementary Conditions and Division 1 Specification Sections, apply to the Work of this Section.

1.2 RELATED WORK

A. Section 31 20 00 "Earthmoving"

1.3 DESCRIPTION OF WORK

A. This Section shall be used as a standard of quality for equipment.

B. Provide and install modular playground structure, complete with all play components, fasteners, supports and footings, ground cover and timber edging. Locate in area indicated on Drawings. Provide ground cover and edging in profile and extent as indicated.

1.4 QUALITY ASSURANCE

A. Safety Requirements: Design playground components to avoid snagging of clothing and entrapment of hands, arms, or other body parts. Equipment shall conform to the following:

1. US Consumer Product Safety Commission (US CPSC) Guidelines: Handbook for Public Playground Safety.

B. Single Source Responsibility: All playground components and accessories shall be supplied by one manufacturer.

C. Erection of the equipment shall be performed by an installer authorized and approved by the Manufacturer.

1.5 SUBMITTALS

A. Product Data: Submit Manufacturer's technical data for materials, including catalog information for major components, anchors, fasteners and other accessories along with information on finishes. Provide Manufacturer's standard installation procedures.

1. Submit location of product manufacture and of extraction/recovery of primary raw materials.
2. Submit recycled-content data, designating percentages of post-consumer and post-industrial recycled material.
3. Submit certification of non-CCA wood treatment for timber edging.

B. Shop Drawings: Submit shop drawings indicating layout of specified components, details for anchoring and fastening of individual components, details of support and foundations, and any other fabrication or erection information not fully described by the product literature.

1.6 WARRANTIES

A. Provide Manufacturer's standard warranty on main support components to cover structural failure due to corrosion, deterioration or defects in workmanship.

B. Provide Manufacturer's standard one (1) year warranty covering defects in materials and workmanship for playground components except as noted below:

1. Structural (Main Components): ten (10) years
2. Plastic: five (5) years

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Game Time c/o West Recreation
   a. Vendor ID # 6694
   b. P.O. Box 487, Queenstown, Maryland 21658
   c. 800.233.0529
B. Max Play Fit, LLC
   a. Vendor ID # 15341
   b. 1945 Melson Way, Hockessin, Delaware 19707
   c. 800.574.3033
C. Playground Specialists, Inc.
   a. Vendor ID # 12519
   b. 17352 North Seton Avenue, Emmitsburg, Maryland 21727
   c. 301.271.9234
D. Taylor Sports and Recreation
   a. Vendor ID # 974
   b. P.O. Box 1706, Martinsburg, West Virginia 25402
   c. 304.263.7857

2.2 MATERIALS

A. General Design Requirements

1. Straight Slides (including pipe slides) without transition sections at the base of the slide shall not exceed 30 degrees of incline. Slide "fall zones" shall comply with US CPSC guidelines.
2. Provide adequate "no encroachment zone" around entire perimeter of playground area.
3. Overall height of equipment shall not exceed 6'-6", except for fireman's poles which shall not exceed 10 feet in height.
4. Fastening, Fabrication and Finish details: Protruding bolts, sharp or jagged edges, non-capped open-ended pipes or other openings shall not be acceptable. Piping or other supports shall not extend more than 2" beyond a locking collar.
5. Foundations: The minimum specifications for the diameter, depth and excavation of footings shall be as follows:
   a. Poles up to and including 6" in diameter: 12" in diameter and 3 feet in depth.

b. Poles exceeding 6" in diameter: Diameter shall be twice the pole diameter and 3 feet in depth.

B. Ground Cover and Drainage: Provide treated wood mulch over the entire area indicated on the drawings, to a minimum depth of 12". Coordinate with drawings to ensure adequate drainage under the ground cover, and to avoid ponding. Maximum allowable slope shall be 2%.

1. Acceptable ground covers: "Surflex", "Fibar", "Wood Carpet", or approved equal.

C. Edging: Provide timber border around entire perimeter. Timber shall be pressure treated for ground contact with non-CCA treatment materials (0.40 #2 or better; ACQ is an acceptable wood treatment)); recycled and/or creosoted timber shall not be acceptable.

1. All edges shall be 1/2" radius.
2. All lumber shall be free from splinters.
3. Two tiers of lumber shall be provided with rowlock or half-lapped joints. Bottom tier of lumber shall be staked to the ground with steel rods reinforcing bars, 1/2" round, 36" on center, and 24" deep.
4. Top and bottom tiers shall be spiked together using galvanized fasteners.

D. Support Posts: 5" O. D., 11 gauge minimum galvanized steel with plastic coated end caps.

E. Fasteners: Provide self-locking nuts or other devices to prevent loosening of assemblies. All fasteners shall be galvanized, cadmium plated, or otherwise treated to prevent rusting.

F. Metal Decks: Perforated, non-skid.

G. Fireman's Pole (Sliding Pole): Fabricated from 1 5/8" O. D. galvanized steel pipe.

H. Spiral Slide: Polyethylene composition with the following features:

1. Center Tube: 3 1/2" O. D. 11 gauge minimum galvanized steel.
2. Front Leg: 1 1/2" O. D. 11 gauge minimum galvanized steel.
3. Slide shall rest flush on the upper platform.

I. "Ring Trek" Traveling Rings: Provide six (6) high tensile strength aluminum rings, plastic coated, with swivel joint and clamp attachment to supports. Beam:
2 3/8" O. D., galvanized.

J. "Curly" Climber:

1. General: Climber shall have no gaps greater than 3 1/2", and less than 9" between coils. Design shall not allow passage of children into the interior of the coil.
2. Coils shall be fabricated from not less than 1 5/6" O. D. galvanized steel pipe.
3. Center support post shall be fabricated from not less than 1 5/8" O. D. galvanized steel pipe.

K. Double Wide Plastic Slide: Single piece, UV stabilized molded polyethylene with average thickness of 5/16" and integral color. Sides shall be 8" high above the slide surface; center divider shall not have gaps. Width of slide bedway shall be 16" minimum.

L. Horizontal "Challenge" Ladder: 2 3/8" O. D. galvanized plastic-covered outside rails, with eight (8) rungs consisting of 1 1/4" O. D. galvanized steel welded to the rails at 12" on center.

M. Arched Chain Climber: One-piece, all welded construction. Side rails shall be 1 5/8" O.C. galvanized steel pipe, arched, and spaced 30" center to center. Chain: 4/0 steel with oven cured PVC "no pinch coating"; or galvanized coating.

N. Recycled-plastic: Recycled HDPE or other recycled plastic components may be used if approved in advance by FCPS.

PART 3 - EXECUTION

3.1 INSPECTION

A. Installer and Owner's Representative shall examine the area and conditions under which the playground equipment will be installed. Do not proceed until all conditions, which would be detrimental to the installation, are corrected.

3.2 INSTALLATION

A. General: Install the playground equipment in accordance with the Manufacturer's recommended procedures and installation sequence. All equipment shall be rigid, straight, plumb and level. Secure all equipment with Manufacturer's fastening devices.

B. Foundations: All support holes shall be filled with concrete to the full-required depth. The top of the concrete shall be 6" below finished grade. All primary supports shall be temporarily supported until concrete has sufficiently cured.

C. Secure timber edging in place by spiking as specified herein. Rods shall not protrude beyond the face of the timber.

D. Fasteners: All in-place bolts shall be cut flush with the nut, and peened and filed. Self-locking nuts or other devices must be provided to prevent nut and bolt assemblies from loosening or coming apart.

E. Welds: Ensure that all welds are protected with rust inhibiting paint.

F. Metal Connectors: Secure with pins or spot welding to prevent loosening of the connection.

3.3 CLEAN-UP

A. Remove all debris, excess materials, tools and excess excavation spoils from the project area and dispose of legally.

3.4 WASTE MANAGEMENT

A. Recycle waste materials in accordance with Division 1 “Construction Waste Management” requirements.

- END OF SECTION 32 30 10 -

SPECIFICATIONS--ELEMENTARY APPARATUS PROPOSAL FOR AGES 2-12

1. Number of Participants
The number of students may range from one class of approximately 30 students, an entire grade level of students, to multiple grade levels at the same time of approximately 200 students. Each playground apparatus; one for grades PreK/K (K-100), one for grades 1-2 (P-200), and one for grades3-5 (I-300) shall allow for a child capacity of at least 75 students and include the elements listed below.

2. Space Requirements
Three separate Playground *types* of Apparatus Areas shall include:
K -100 - Pre-Kindergarten and Kindergarten Play Area (certified for ages 2-5)
P -200 - Primary area (certified for ages 5-12)
I - 300 - Intermediate area (certified for ages 5-12)

3. Specifications (minimum)
3.1. Manufacturer must be ISO 9001/2000 certified and have IPEMA certification for each component that shows conformance to ASTM-F1487-07ael

3.2. The Pre-K/K area will be fenced. (by others)

3.3. Each area must be ADA accessible.

3.4. Safety surfacing shall be engineered wood fiber for all three playgrounds apparatus areas. Surfacing that is more ADA-friendly (especially for wheelchairs), such as poured-in-place rubber surfacing will be bid as an alternate.

3.5. Playground apparatus hardware shall be stainless steel that resists rust and corrosion and is tamper-proof.

3.6. Playground apparatus decks and tubing shall be constructed with 12-gauge steel.

3.7. Playground apparatus powder coating shall be resistant to chipping and color fade resistant.

3.8. Playground apparatus shall have a minimum of 5-inch diameter posts for grade 1-5 and 3 ½ inch diameter posts (minimum) for the PreK-K area.

3.9. Playground apparatus component attachments should not overlap deck surfaces.

3.10. There shall be an eight foot maximum deck height for the I-300 (grades 3-5) area, a six foot maximum deck height for the P-200 (grades 1-2 area), and a five foot maximum deck height for the K-100 (grades PreK-K) area.

3.11. There shall be an element of flow and continuous movement among all of the elements of the playground apparatus. This element of flow shall allow students to develop their cardio-respiratory endurance as well as their muscular strength and endurance as they move through the playground apparatus.

4. FCPS Minimum Standards for Each Playground Apparatus Area
*NOTE: **Many playground apparatus components can incorporate multiple elements.*
4.1 Spinning/ Swinging/ Swiveling
4.1.1 There shall be a minimum of four swinging/ spinning/ swiveling elements. "Traditional" swings (with bays as a separate apparatus) shall not be included.

4.1.2 On the *K -100* - Pre-Kindergarten and Kindergarten Play Area (certified for ages 2-5) There shall be a minimum of one swinging/spinning/swiveling element

4.2 Climbing and Brachiating
4.2.1 For the P-200 and I-300 Playgrounds, a minimum of 6 components shall be provided for climber and overhead component play. At least two of these components shall provide for brachiating (arm-over-arm) skill development. At least one component shall be a climbing wall that links to a deck no higher than 6 feet. At least one component shall be a net climber. At least one component shall have dynamic motion. At least one component shall link to a deck or other component. At least one component will allow students to perform a pull-up/chin-up exercise. Climbing poles (like a "fireman's pole") shall not be included

4.2.2 On the *K -100* - Pre-Kindergarten and Kindergarten Play Area (certified for ages 2-5) there shall be a minimum of 2 components for climber and overhead component play. One component shall provide for brachiating (arm-over-arm) skill development and shall be short in length

4.3 Sliding
4.3.1 A minimum of 3 slides shall be in place. No tube slides shall be included.

4.4 Balancing and Rocking
4.4.1 A minimum of two balance activities shall be included. Log roll type elements shall not be included.

4.5 Linking Components and Ramps
4.5.1 A minimum of 3 linking components shall be used. At least one component shall incorporate brachiating. At least one component shall incorporate balance skills. At least one component shall incorporate climbing skills. No crawl tubes, tunnels, or track rides type elements shall be included.

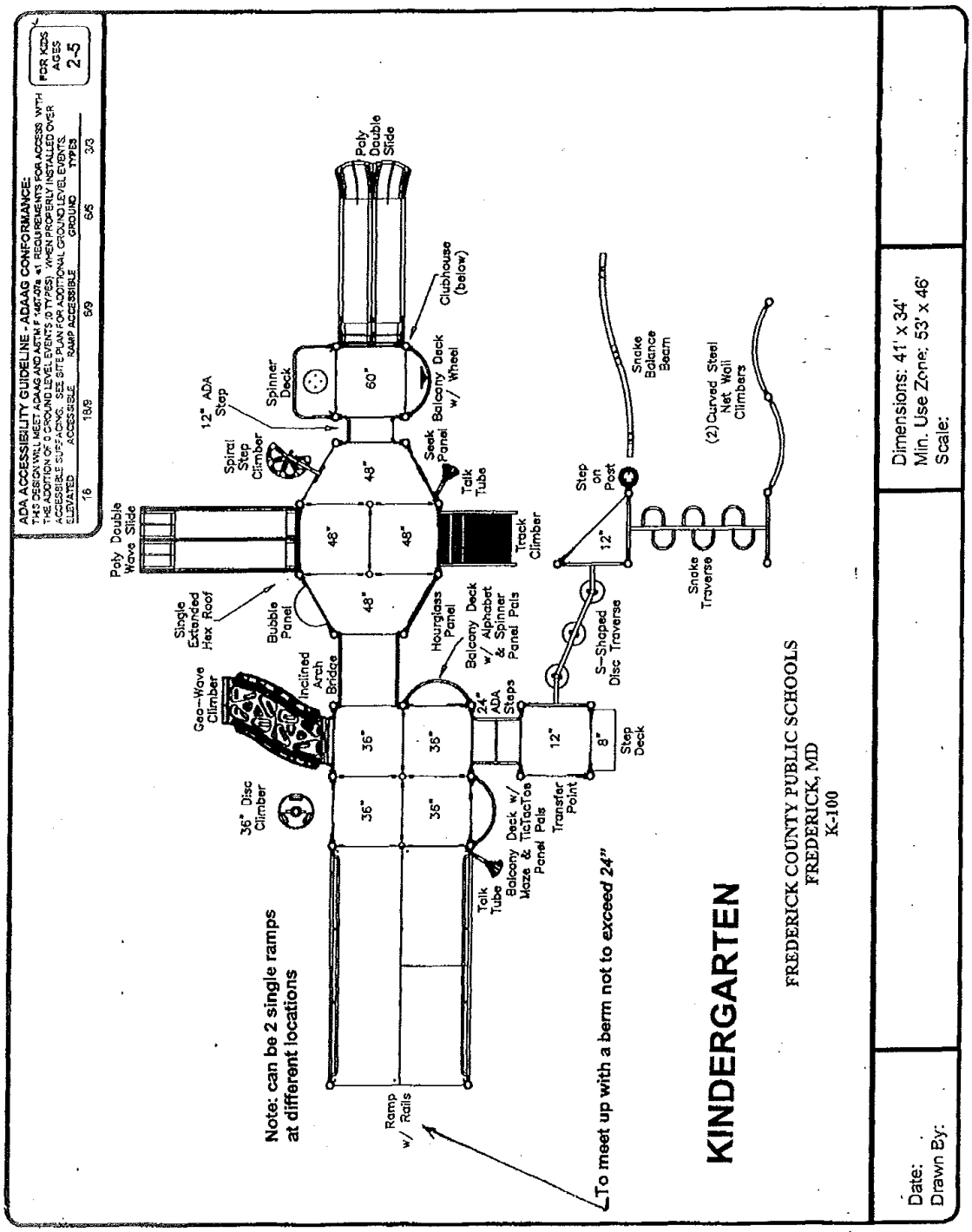
4.5.2 Ramps are linking components used as access for all children, but are necessary for children with disabilities. A minimum of one ADA wide-ramp should be provided to allow access for students to a higher deck height (deck height that is a minimum of 3 feet). The width of this ramp should be a minimum of 74 inches in order to provide dual access for handicapped and typical students. This ramp should provide access to at least four ADA-accessible components

4.6 Panels and ground level play components.
4.6.1 A minimum of two interactive play panels shall be included. At least one panel shall be placed in the "crow's nest" position adjacent to the ramp so that a student in a wheelchair can fully access the component

4.6.2 The space under platforms and decks are places for children to congregate and interact. The roofs provided by this create an enclosed space, and add to its appeal as gathering space. These spaces shall include ground level components; however, supervision of these components shall be considered in their placement.

4.6.3 A minimum of 5 ground level play components that address a variety of needs, including socialization, manipulation, imaginative play, balance, and/or auditory stimulation, shall be included.

4.7 Shade Structures
The majority of the apparatus surface area shall be shaded, with particular care that slides are shades. Shade structures shall be bid as an alternate.


ADA ACCESSIBILITY GUIDELINE - ADAAG CONFORMANCE:
THIS DESIGN WILL MEET ADAAG AND ASTM F 1487-07a #1 REQUIREMENTS FOR ACCESS WITH THE ADDITION OF 0 GROUND LEVEL EVENTS (0 TYPES). WHEN PROPERLY INSTALLED OVER ACCESSIBLE SURFACING. SEE SITE PLAN FOR ADDITIONAL GROUND LEVEL EVENTS.
ELEVATED 16 ACCESSIBLE 18/9 RAMP ACCESSIBLE 6/9 GROUND 6/5 TYPES 3/3
FOR KIDS AGES 2-5
Poly Double Slide
Clubhouse (below)
Spinner Deck
60"
Balcony Deck w/ Wheel
12" ADA Step
Spiral Step Climber
48"
Seek Panel
Talk Tube
Poly Double Wave Slide
48"
48"
Track Climber
Step on Post
12"
Snake Balance Beam
(2) Curved Steel Net Wall Climbers
Snake Traverse
Single Extended Hex Roof
Bubble Panel
48"
Hourglass Panel
Balcony Deck w/ Alphabet & Spinner Panel Pals
S-Shaped Disc Traverse
Geo-Wave Climber
Inclined Arch Bridge
24" ADA Steps
36"
36"
12"
8"
Step Deck
36" Disc Climber
36"
36"
Transfer Point
Balcony Deck w/ Maze & TicTacToe Panel Pals
Talk Tube
Note: can be 2 single ramps at different locations
Ramp w/ Rails
To meet up with a berm not to exceed 24"
KINDERGARTEN
FREDERICK COUNTY PUBLIC SCHOOLS
FREDERICK, MD
K-100
Dimensions: 41' x 34'
Min. Use Zone: 53' x 46'
Scale:
Date:
Drawn By:

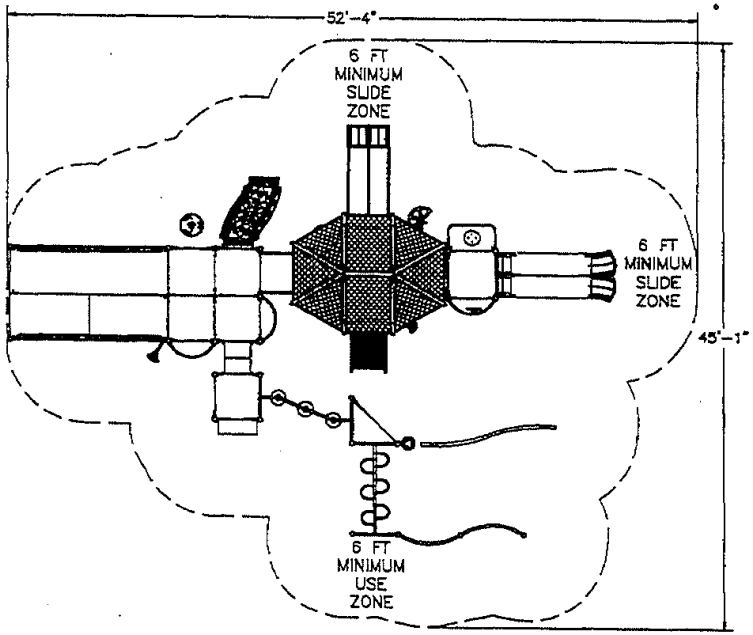
Site Plan

ADA ACCESSIBILITY GUIDELINE - ADAAG CONFORMANCE:
THIS DESIGN WILL MEET ADAAG AND ASTM F 1487-07a e1 REQUIREMENTS FOR ACCESS WITH THE ADDITION OF 0 GROUND LEVEL EVENTS (0 TYPES) WHEN PROPERLY INSTALLED OVER ACCESSIBLE SURFACING.

ELEVATED	ACCESSIBLE	RAMP ACCESSIBLE	GROUND	TYPES
18	18/9	6/9	6/6	3/3

FOR KIDS AGES 2-5

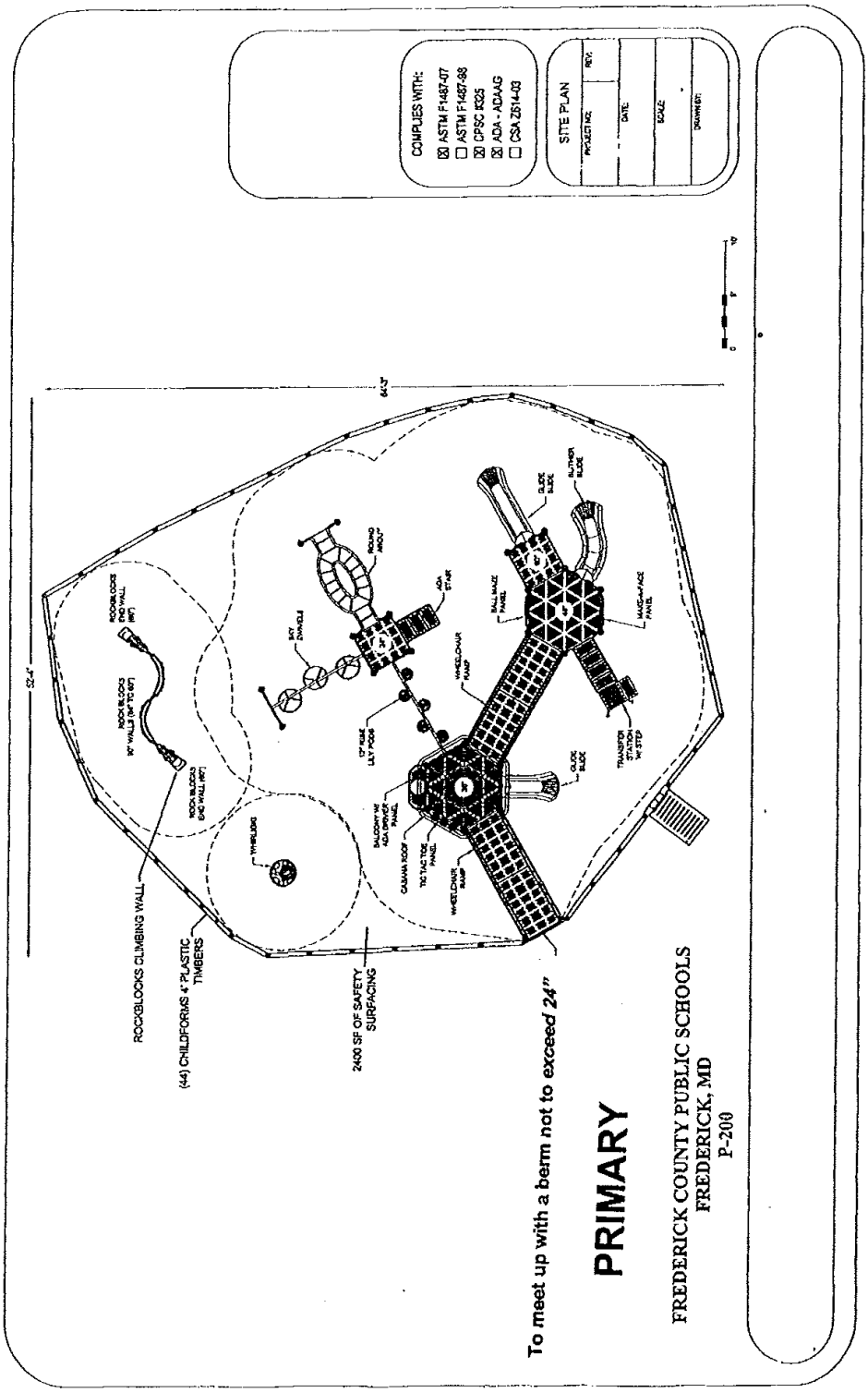
ESTIMATED AREA SQUARE FOOTAGE: 1771 SQ. FT.
ESTIMATED LENGTH OF PERIMETER: 158 FT.

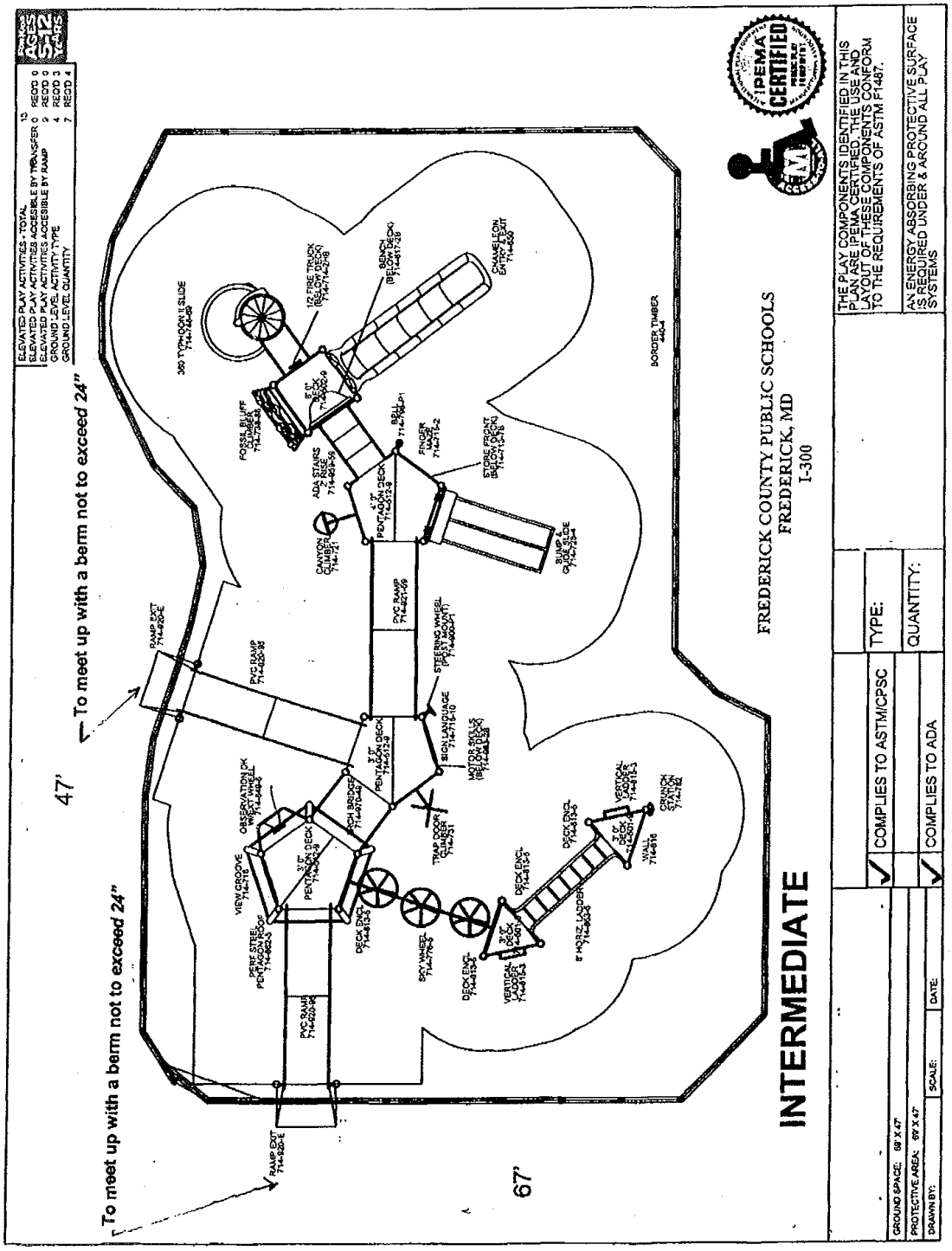


Date:
Drawn By:

KINDERGARTEN

Scale:


COMPLIES WITH:
ASTM F1487-07
ASTM F1487-98
CPSC 8325
ADA - ADAAG
CSA Z614-03
SITE PLAN
PROJECT NO:
REV:
DATE:
SCALE:
DRAWN BY:
ROCKBLOCKS CLIMBING WALL
(44) CHILDFORMS 4" PLASTIC TIMBERS
2400 SF OF SAFETY SURFACING
To meet up with a berm not to exceed 24"
PRIMARY
FREDERICK COUNTY PUBLIC SCHOOLS
FREDERICK, MD
P-200


ELEVATED PLAY ACTIVITES - TOTAL 13 REQ'D 0
ELEVATED PLAY ACTIVITES ACCESIBLE BY TRANSFER 0 REQ'D 0
ELEVATED PLAY ACTIVITES ACCESIBLE BY RAMP 9 REQ'D 0
GROUND LEVEL ACTIVITY TYPE 4 REQ'D 3
GROUND LEVEL QUANTITY 7 REQ'D 4
To meet up with a berm not to exceed 24"
To meet up with a berm not to exceed 24"
47'
67'
FREDERICK COUNTY PUBLIC SCHOOLS
FREDERICK, MD
I-300
INTERMEDIATE
THE PLAY COMPONENTS IDENTIFIED IN THIS PLAN ARE IPEMA CERTIFIED. THE USE AND LAYOUT OF THESE COMPONENTS CONFORM TO THE REQUIREMENTS OF ASTM F1487.
AN ENERGY ABSORBING PROTECTIVE SURFACE IS REQUIRED UNDER & AROUND ALL PLAY SYSTEMS
IPEMA CERTIFIED
TYPE:
COMPLIES TO ASTM/CPSC
QUANTITY:
COMPLIES TO ADA
GROUND SPACE: 98' X 47'
PROTECTIVE AREA: 69' X 47'
DRAWN BY:
SCALE:
DATE:

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including the General Conditions and other Division 1 Specification Sections, apply to the work of this Section.

1.2 SUMMARY

A. This Section includes the following

1. Materials and Work Required to Construct Chain Link Fence and Gates and Related Accessories.

B. Related Sections

1. Section 31 20 00: Earthmoving
2. Section 32 13 15: Concrete Curbing
3. Section 32 12 16: Hot-Mixed Asphalt Pavement

1.3 CODES

A. Existing Underground Utilities: Refer to Section 31 20 00 "Earthmoving".

1.4 STANDARDS

A. Installation shall be per chain link manufacturer’s standards (CLFMI).

1.5 SUBMITTALS

A. Submit manufacturer's descriptive literature, specifications and installation instructions for chain link fence and gates.

B. Submit samples of vinyl-coated fabric 12 by 24 inches.

C. Warranty

1. Submit typewritten vinyl coated fence warranty signed by manufacturer and contractor.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver chain link fencing to the project site in original unopened containers bearing manufacturer's label.

1.7 QUALITY ASSURANCE

A. Provide complete fencing (of each type) produced by a single manufacturer.

1.8 PROJECT CONDITIONS

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Limitations: Do not proceed with fencing installation until underground utility, bituminous concrete pavement and concrete curb and gutter construction is complete.

1.9 WARRANTY

A. Warrant vinyl coated fencing for 10 years against peeling, cracking and corrosion.

1.10 CONSTRUCTION SURVEYS

A. Retain the services of a locally registered land surveyor or professional engineer to provide horizontal alignment stakes for fencing located adjacent to site property lines. Horizontal stake interval 50 feet maximum, and at all angle points along property line.

B. Provide horizontal alignment stakes for project site fencing. Horizontal stake interval 50 feet maximum and at all corner points.

PART 2 - PRODUCTS

2.1 CHAIN LINK FENCING

A. Acceptable Manufacturers, giving preference to products manufactured within a 500-mile radius of the Project Site:

1. Anchor Fencing
2. Sonco Fence
3. Long Fence
4. P&H Tube Division/Southwestern Pipe
5. Allied Tube and Conduit Corp.
6. Other pre-bid approved manufacturer(s) meeting the requirements of this Specification Section will be considered in accordance with Specification Section 01 60 00: Product Requirements.

B. General: Posts, rails, braces and bracing assemblies shall be high tensile steel pipe, cold-rolled and electric resistance welded from steel conforming to ASTM A 569, and hot-dip galvanized to ASTM A 525 G-90 zinc weight both inside and outside the pipe.

C. Finish: The outsides shall receive a conversion coating and fusion bonded polyester powder coating equivalent to "Lifecoat LCX" by P & H Tube. Coating color shall be black.
1. All fencing except shall have bottom tension wire.

2. All fencing shall have continuous top rail.

D. Fabric: 9-gauge (0.148-inch) core size, finished steel wires, galvanized in accordance with ASTM A 641-71a. Finish shall be thermally bonded PVC over galvanized steel, Class 2B, in accordance with ASTM F 668. Coating color shall be black. Fabric shall have 2-inch diamond mesh pattern with top and bottom selvages knuckled.

E. Fencing and gate around generator and transformer shall be-chain link.

F. Posts, Rails and Braces

1. Terminal Posts (Corner Posts): Up to 6 feet: 2.375 inch O.D.; over 6 feet: 2.875 inch O.D.

2. Line Posts: Up to 6 feet: 1.90 inch O.D.; over 6 feet: 2.375 inch O.D.

3. Gate Posts (Hinge Posts): Leaf widths up to 6 feet: 2.875 inch O.D.; leaf widths 6 feet to 13 feet: 4.00 inch O.D.

4. Top Rail, Center Rail and Bottom Rail: Manufacturer's longest lengths, with expansion couplings (approximately 6 inches long) for each joint. Provide means of attaching top rail securely to each corner, end, and pull post.

5. Terminal and Gate Post Bracing Assemblies: Manufacturer's standard adjustable brace at end posts and at both sides of corner and pull posts, with horizontal brace located at mid-height of fabric. Use same material as top rail for braces. Brace line posts with 0.375-inch diameter rod and adjustable tightener.

6. Stretcher Bars: One-piece lengths equal to full height of fabric, with minimum cross section of 3/16" x 3/4". Provide one stretcher bar at each end post and two for each corner and pull post, except where fabric is integrally woven into post.

G. Gates

1. Gate framing shall be 2-inch square aluminum tube with fabric installed inside the frame with "J" bolts.
2. Hinges shall be manufacturer's standards.
3. Latches shall be butterfly type.
4. Height shall match adjacent fencing fabric, leaf swings 180 degrees.

H. Bottom Tension Wire: 7-gauge, O.D. = 0.177-inch core size, with PVC coating.

I. Post Tops (Caps): Weathertight closure caps, dome type, at each post, with openings to permit passage of top rails.

J. Hardware and Accessories: Galvanized per ASTM A 152 with manufacturer's standard polyvinyl chloride (PVC) plastic resin finish over galvanizing, not less than 0.010" thick.

2.2 CHAIN LINK FENCING HEIGHTS

A. Heights shall be as indicated or as specified:

2.3 PADLOCKS

A. Padlocks manufactured by Master Lock Company, Milwaukee, Wisconsin. Provide one "Steel Secret Service" lock and furnish Owner with two keys for each gate.

2.4 CONCRETE:

A. Class "B" Portland cement concrete, Specification Section 33 10 00: "Utility Standards".

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Existing Utilities: Verify utility locations prior to fencing excavation operation. Adjust horizontal fencing alignment to avoid utilities at no increase to contract sum.

3.2 GRADING

A. Grade fence lines to smooth and uniform surfaces, free of depressions and high spots exceeding four inches in ten feet.

3.3 CHAIN LINK FENCING

A. General: Install in accordance with manufacturer's installation instructions and as noted. Install corner posts at horizontal alignment changes exceeding 30 degrees. Install line posts at intervals not exceeding ten feet. Install gateposts on both sides of gate opening.

B. Post Installation:
   1. Excavate post footings to minimum 18-inch diameters and 39 inch depths or as otherwise indicated.

   2. Place and consolidate concrete in footing excavations. Install posts in concrete plumb to 1/4 inch in 10 feet. Provide bracing to prevent movement. Embed line post in concrete to 18 inches, terminal and gate posts to 24 inches. Slope exposed concrete footing surface one inch with outside edge flush with ground surface. Trowel exposed concrete footing surface to smooth finish. Contractor shall allow concrete footings to cure a minimum of 14 calendar days before removing bracing, or performing subsequent fencing operations.

C. Terminal and Gate Post Bracing Assemblies, Truss Rods and Tighteners and Tension Wire and Post Tops: Install in accordance with manufacturer's installation instructions and as specified.

D. Fabric: Each span shall be attached independently at pull and corner posts. Ends of fabric rolls and other section to be spliced shall be joined by weaving a single strand of the fabric wire into ends of the fabric to create a continuous pattern of mesh. Fabric shall be stretched taut and securely fastened to each post and rail. Fastenings at ends, gates, corners, and pull posts shall be with stretcher bars and metal bands.

3.4 MAINTENANCE

A. Refer to Section 31 20 00 "Earthmoving".

- END OF SECTION 32 31 13 -

SECTION 32 32 23
SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Modular block retaining wall system.
2. Precast concrete retaining wall caps.

B. Related Sections include the following:

1. Division 2, Section 31 20 00, "Earthmoving"

1.3 PERFORMANCE REQUIREMENTS

A. Employ a qualified Professional Engineer licensed in the State of Maryland to design all segmental block retaining walls in accordance with the wall manufacturer's specifications and based upon information, including, but not limited to, soil properties, bearing capacities, and existing and proposed construction provided in the project Geotechnical Engineering Report and shown on the Contract Drawings, plans, profiles, details and notes. Review and request clarification of any information provided prior to submittal of bid to ensure that all Work costs are included in the Contractor's bid.

B. Design and construct all segmental block retaining walls to be capable of resisting all soil, hydrostatic and other applied pressures. Provide all wall construction, wall materials, backfill materials, geo-grid and/or other soil reinforcement materials required to accomplish this at no additional cost to the Owner.

C. Design and construct all segmental block retaining walls to lines and grades indicated on the Contract Drawings and to other dimensions and depths required so as not to de-stabilize or be de-stabilized by, or undermine or be undermined by, adjacent construction.

D. Install segmental retaining walls without damaging existing buildings, pavements, and other adjacent site improvements.

E. Obtain building permit for segmental retaining walls from authorities having jurisdiction. Submit a copy of said permit to the Owner for record.

1.4 SUBMITTALS

A. Product Data: Include data for proposed materials, method of installation, and list of materials proposed for use.

1. Material description and installation instructions for each manufactured product specified including Segmental Retaining Wall Units (SRW) and Geosynthetic Reinforcement.

2. Name and address of the production facility where the proposed SRW units will be manufactured. All units to be manufactured at the same facility.
3. Notarized letter from the SRW manufacturer stating that the units supplied for this project are manufactured in complete compliance with Section 2.3 of this specification. The letter shall state that the SRW units shown in the attached test reports are representative samples of the plants normal mix design and regular production runs. Include location of product manufacture.

B. Shop Drawings, System Designs and Calculations: Prepared by or under the direct supervision of a qualified Professional Engineer licensed in the State of Maryland who is experienced in the design of the proposed segmental retaining wall system. Include drawings and comprehensive engineering analysis that shows the system's compliance with specified requirements. Engineering design calculations prepared in accordance with the NCMA Design Manual for Segmental Retaining Walls, most current edition. Analysis shall include: Internal, External, Global Stability, and Bearing Capacity Calculations. System designs, materials, calculations and shop drawing must be signed and sealed by the qualified professional engineer responsible for their preparation and must be submitted to, reviewed by, and bear the approval stamp of authorities having jurisdiction prior to their submittal for review and approval by the Architect, Engineer and/or the Owner.

C. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available for each type of concrete units required shall be submitted to the Architect and Owner for review and approval.

D. Samples for Verification: Full-size units of each type of concrete unit for each color, texture, and pattern specified, showing the full range of variations expected in these characteristics.

E. Test Reports:

1. Independent laboratory reports indicating compressive strength, moisture absorption and freeze-thaw durability of the concrete retaining wall units from the proposed production facility. Only test performed within the past 12 months will be considered current and valid.
2. Independent test reports verifying the long-term design strength properties (creep, installation damage, and durability) and soil interaction properties of the geosynthetic reinforcement.
3. Independent test reports verifying the connection capacity between the geosynthetic reinforcement and the concrete retaining wall units.
4. For projects with walls in excess of 25’ in height, a completed Highway Innovative Technology Evaluation Center (HITEC) report shall be required for the proposed system.

F. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of Architects and Owners, and other information specified.

G. LEED Submittals

1. Product data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

2. Product data for Credit MR 5: For products having regional material content, documentation indicating location of manufacture and location of extraction, recovery or harvest of primary raw materials. Include statement indicating cost of each product with regional material content.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed segmental retaining wall installations similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance. The Retaining Wall Company must have successfully completed the Segmental Retaining Wall training and exam of the National Concrete and Masonry Association.

B. Source Limitations: Obtain each type of concrete unit from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

C. Engineering Responsibility: Contractor shall engage a qualified Professional Engineer who will be responsible for the preparation of designs and data for the segmental retaining walls including drawings and comprehensive engineering analysis that shows the system's compliance with specified requirements.

D. Professional Engineer Qualifications: A professional engineer, in good standing, who is legally qualified and currently licensed to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services for designing segmental retaining walls that are similar to those indicated for this Project in material, design, and extent.

E. Arrange for and obtain any required inspections and certifications by authorities having jurisdiction.

F. Provide as-built information as required by contract and by authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect materials during storage and construction from earth and other materials. Protect segmental retaining wall materials from damage. Do not incorporate damaged materials into the retaining wall structure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following, giving preference to products manufactured within a 500-mile radius of the Project Site:

1. Available Manufacturers:
   a. Versa-Lok Retaining Wall Systems
   b. Keystone Retaining Wall Systems, Inc.
   c. Anchor Wall Systems
   d. Tensar Earth Technologies, Inc.

e. Rockwood Retaining Walls, Inc.
f. Cornerstone Wall Solutions, Inc.

2.2 COLORS AND TEXTURES

A. Colors and Textures:
1. Modular Block Retaining Wall Units: As selected by Architect from manufacturer's full range.
2. Precast Concrete Retaining Wall Caps: Match color of color-conditioned concrete retaining wall.

2.3 MODULAR CONCRETE RETAINING WALL SYSTEM

A. Modular Concrete Retaining Wall System: Use wall system materials and construct in accordance with the wall engineer's design and wall manufacturer's specifications to meet all performance requirements set forth in this specification.

B. Concrete Units: Comply with ASTM C1372 and the following requirements:

1. Face Finish: Sculptured rock face in angular tri-planar configuration or as otherwise approved by the Owner.
2. Strength: Minimum 28-day compressive strength of 3000 psi.
3. Maximum Moisture Absorption: 8 percent.
4. Concrete Units: Provide concrete units, mini, cap and end units provided by the wall manufacturer for use with the selected wall system and as required to meet the performance requirements set forth in this specification.

C. Base Leveling Pad Material: Provide and install continuous footing or base material required by the wall manufacturer and wall engineer for use with the selected wall system to meet the performance requirements set forth in this specification. Do not exceed soil bearing limitations.

D. Unit Fill: Provide and install unit fill material required by the wall manufacturer and wall engineer for use with the selected wall system to meet the performance requirements set forth in this specification.

E. Backfill Material: Provide and install backfill material required by the wall manufacturer and wall engineer for use with the selected wall system to meet the performance requirements set forth in this specification. Where possible use site excavated soils. Do not use unsuitable soil for backfill. Comply with Section 31 20 00 "Earthmoving" for backfill requirements.

F. Soil and Wall Reinforcement/Stabilization: Provide and install all temporary and/or permanent soil and wall reinforcement and stabilization materials required by the wall manufacturer and wall engineer for use with the selected wall system to meet the performance requirements set forth in this specification. Such materials include, but are not limited to, high density polyethylene expanded sheet, polyester woven fiber materials, mechanical anchors, sheeting, shoring and bracing specifically fabricated for use as soil reinforcement.

G. Non-Corrosive Connectors: Provide all pins, clips, or bars to connect successive horizontal rows of concrete blocks, possessing a verifiable strength and durability consistent with

the design calculations of the wall as a whole and as required by the wall manufacturer and wall engineer for use with the selected wall system to meet the performance requirements set forth in this specification.

H. Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

2.4 CONCRETE RETAINING WALL CAPS

Except as otherwise required or recommended by the wall manufacturer and the contractor's wall Engineer for use with the selected wall system and to meet the performance requirements set forth in this specification, retaining wall caps will meet the following minimum specifications:

A. Structural Performance: Provide precast concrete wall cap units and connections capable of withstanding design loads within limits and under conditions indicated.

B. Materials: Comply with PCI MNL 117 and the following:

1. Molds: Provide molds and, where required, form-facing materials of metal, plastic, wood or another material that is nonreactive with concrete and dimensionally stable to produce continuous and true precast concrete surfaces within fabrication tolerances and suitable for required finishes.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
3. Portland Cement: ASTM C 150, Type I or III.
4. Normal-Weight Aggregates: Washed, inert, natural sand, or well-graded crushed stone or gravel complying with ASTM A 33 and matching aggregate used in cast-in-place retaining wall.
5. Lightweight Aggregates: ASTM C 330.
6. Air-Entraining Admixture: ASTM C 260, certified by manufacture to be compatible with other required admixtures.

C. Accessories

1. Dowels: Round stainless steel bars complying with ASTM A 276, Type 304, ½-inch diameter.

D. Concrete Mix: Prepare design mixes for each type of concrete required. Design mixes may be prepared by a qualified independent testing agency or by qualified precast plant personnel.
1. Compressive Strength (28 Days): 5000 psi.
2. Maximum Water-Cement Materials Ratio: 0.45.

2.5 RETAINING WALL GUARD RAILS

A. Guard Rail or Fence shall be placed directly into the cap of the retaining wall as indicated on the drawings. The engineer will be responsible for designing the wall to account for loading onto the guardrail or fence that will be mounted into the cap. Placing the guard rail or fence outside of the cap will not be accepted or approved.

PART 3 - EXECUTION

3.1 PREPARATION

A. Place leveling materials upon approved foundation to a minimum thickness of 6 inches. Compact material to provide a level surface. Compaction shall be 95 percent of Standard Proctor for sand or gravel type materials. Prepare leveling pad to ensure complete contact of retaining wall unit with base.

3.2 SEGMENTAL RETAINING WALL INSTALLATION

A. Install segmental retaining walls according to modular concrete unit manufacturer's written instructions and the approved shop drawings. Use wall system materials and construct in accordance with the wall engineer's design and wall manufacturer's specifications to meet all performance requirements set forth in this specification.

B. Except as otherwise required or recommended by the wall manufacturer and the contractor's wall engineer for construction of the selected wall system to meet the performance requirements set forth in this specification, retaining wall construction will meet the following minimum specifications:

1. Place first course of concrete wall units on base leveling pad. Check units for levelness and alignment. Ensure that units are in full contact with base.
2. Place units side by side for full length of wall alignment. Install non-corrosive connectors and fill voids at units with unit fill material as required by manufacturer. Tamp fill.
3. Sweep excess material from top of units and install next course. Ensure each course is complete unit filled and compacted prior to proceeding to next course.
4. Install Soil and Wall Reinforcement/Stabilization system, backfill and continue to lay up wall according to modular concrete unit manufacturer's written instructions and the approved shop drawings. When using geogrid, lay geogrid soil reinforcement horizontally on compacted backfill and connect to concrete wall units as indicated on manufacturer's shop drawings. Pull geogrid taut and anchor before backfill is placed on it.

3.3 CONCRETE WALL CAP INSTALLATION

A. Except as otherwise required or recommended by the wall manufacturer and the contractor's wall engineer for construction of the selected wall system to meet the performance requirements set forth in this specification, the installation of the precise wall cap will meet the following minimum specifications:

1. Caps shall be formed in the field of concrete, and anchored to the top of the wall per the manufacturer's recommendations.
2. Precast caps are not acceptable.

3.4 CONSTRUCTION TOLERANCES

A. Except as otherwise required or recommended by the wall manufacturer and the contractor's wall engineer for construction of the selected wall system to meet the performance requirements set forth in this specification, the installation of the precise wall cap will comply with the following as-built construction tolerances:

1. Vertical Alignment: Do not vary from plumb by more than 1-1/2 inches over any 10-ft distance.

2. Wall Batter: Do not vary more than 1 degrees of design batter.

3. Horizontal Alignment: Do not vary more than 1-1/2 inches over any 10-ft distance.
4. Corners, Bends and Curves: Do not vary 1-ft to theoretical location.
5. Maximum Horizontal Gap Between Erected Units: ½-inch.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to provide quality assurance and testing services during construction. Quality testing shall include foundation soil inspection, soil and backfill testing, and observation of construction.
   1. Testing Frequency:
      a. One test for every 2 feet (vertical) of fill placed and compacted, for every 50 lineal feet of retaining wall.
      b. Vary compaction test locations to cover the entire area of the reinforced soil zone, including the area compacted by the hand-operated compaction equipment.

- END OF SECTION 32 32 23 -

SECTION 32 90 00
TREE CONSERVATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies labor, materials, and equipment and services necessary for and reasonably incidental to preservation, protection and care of trees as shown on the Drawings, specified or directed.

1.2 QUALITY ASSURANCE

A. Methods for tree preservation and protection shall conform to details shown on the Drawings and any pertinent nationally recognized standards.

B. The Contractor shall during pre-construction activities, construction activities and post-construction activities employ an ISA (International Society of Arboriculture) certified arborist with a minimum of two years experience in tree preservation. The Contractor shall submit documentation that arborist has the above qualifications.

C. The arborist shall be on-site at any time work is being performed in the vicinity of trees to supervise implementation of procedures for tree protection, to monitor tree health during construction operations and the installation of pipes, curbs, sidewalks, etc and to supervise any repair of damages after construction.

1.3 SUBMITTALS

A. Provide written report by a certified arborist identifying root evaluations of the trees, which are in potential conflict with construction to determine the critical root zones.

B. Provide written report by a certified arborist indicating the best methods of construction, which will minimize the impact on the critical root zone. Obtain specifications from the arborist for individual tree protection and maintenance as required for the identified to be saved on the Drawings.

PART 2 - PRODUCTS

2.1 TREE PROTECTION DEVICE

C. Fencing shall be tenax alpi. It shall be blaze orange plastic mesh at least forty-eight (48) inches in height, with grid openings not greater than three (3) inches in width.

2.2 SOIL AMENDMENTS

D. Suitable organic matter shall be peat moss, composted manure, deactivated sewage sludge or similar material as approved by the arborist or engineer.

E. Special soil mixture is composed of one part suitable organic matter and 6 parts backfill. Backfill material shall be loose, fine, friable, even textured loam. The mixture shall not contain any rock fragments larger than four (4) inches in any direction, nor construction debris of any sort.

PART 3 - EXECUTION

3.1 PRECONSTRUCTION ACTIVITIES

F. The limits of disturbance shall be located and flagged by the Contractor in the field prior to any stress reduction or construction activities. Limits of Disturbance shall be placed outside of critical root zones of trees to be preserved wherever possible.

G. As shown on the plans, trees which are to be preserved shall have their roots pruned. Root pruning trenches shall be located within one foot of limits of disturbance. Roots shall be cleanly cut to a depth of at least 24 inches using a vibratory plow (cable laying machine), tooth-chain trencher or other acceptable equipment. Fill trench as soon as possible with soil mixture herein described and pack to eliminate air pockets.

H. Fertilize trees in construction area at the rate of 3 pounds of nitrogen per 1000 square feet of root zone disturbed. Apply fertilizer to entire critical root zone out to root pruning trench. Fertilizer should be at least 50 percent (50%) slow release nitrogen and contain other essential elements and micronutrients.

I. Water critical root zone immediately after applying fertilizer to saturate the top 6 inches of soil.

J. A mulch 2-4 inches deep comprised of weed-free straw, woodchips, shredded bark or leaves shall be applied in the critical root zone adjacent to the pruning trench. Mulching shall not extend farther than 20 feet from the pruning trench.

K. Trees which are dead or dying or are in poor condition prior to the start of construction shall be flagged and recorded on the plan.

L. Blaze Orange Plastic Mesh Fence
   1. All tree Preservation Areas shall be surrounded by blaze orange plastic mesh fences.
   2. Boundaries of fencing shall be staked, flagged and approved prior to installation.
   3. All fencing shall be installed prior to construction activities.
   4. Fences shall be firmly anchored at a spacing no greater than eight (8) feet and constructed in a manner which precludes sagging.
   5. All fencing shall be maintained in a good condition and promptly repaired or restored as the situation warrants.

3.2 CONSTRUCTION PHASE

A. Any on-site decisions regarding conditions or activities which may be injurious to the health of certain specimen trees in the vicinity of the construction area shall be made in consultation with the specified arborist.

B. Excavated and backfill material shall not be placed or side cast within the critical root zones of trees to be preserved.

C. Construction equipment shall not be driven into or through protected trees, nor shall swinging cranes or backhoes be allowed in their canopies.

D. There shall be no stacking or storing supplies within the critical root zones of trees to be preserved.

E. Trees to be removed shall be taken out without damaging protected trees.

F. There shall be no burning in or close to protected trees.

G. Changing site grades which will cause drainage to flow into or to collect near protected trees shall be prohibited. All grading shall take place outside the critical root zone of the trees to be protected.

H. All equipment shall be kept outside the blaze orange fencing.

I. In the event of drought, the protected trees shall be monitored for signs of stress and watered as needed or as directed by the arborist.

J. The certified arborist shall also monitor trees to be preserved for any other conditions or activities not mentioned above which may be injurious to their health.

3.3 POST-CONSTRUCTION ACTIVITIES

A. Repair & Care of Tree Damages

1. The ends of any additional roots damaged or cut during the construction phase of the project which have not already been pruned and dressed at the outset of the project shall be cut off smoothly. Then peat moss or other suitable organic matter shall be added to the backfill material at a ratio of 1 part organic matter to 6 parts backfill. Fill and pack around roots to avoid air spaces. Restore grades to preconstruction elevations.

2. Damaged limbs and dead limbs shall be removed if a safety hazard or if injurious to the health of the tree. Tree crown reduction procedures may be employed to promote the health of a tree and shall be performed by a certified arborist.

3. If a tree is wounded during construction, under direction of the arborist, wounds should be cleaned, torn bark cut, and if possible the wounds dressed in a shape like a vertical ellipse, to facilitate rapid healing. Pruning knife shall be sharp and clean.

4. Unless directed otherwise by the arborist, any compacted soil within the critical root zone of the trees to be preserved shall be mechanically aerated to a depth of eight (8) inches. Aeration holes should be spaced one foot on center and should be positioned to avoid severing major roots.

5. The arborist shall inspect and review the trees within one-year after completion of construction and determine if the trees can be safely fertilized. The arborist shall make the initial fertilizer application and provide written instructions and information to the owner on successive fertilizer applications. After completion of construction the arborist shall perform Class II pruning on all trees to remove any damaged, dead, interfering and objectionable limbs one half inch in diameter and larger. The arborist shall selectively thin the trees to properly shape the canopy, reduce wind resistance and the possibility of storm damage.

3.4 REMOVAL OF TEMPORARY STRUCTURES

A. Remove blaze orange fencing.

B. Re-seed or sod disturbed areas in accordance with the Contract Documents.

- END OF SECTION 32 90 00 -

SECTION 32 93 05
TOPSOILING, SEEDING AND SODDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 through Division 16 Specification Sections, apply to the Work of this Section.

1.2 RELATED WORK

A. Earthmoving: Section 31 20 00

B. Landscaping: Refer to Civil Drawings and Section 32 95 00.

C. Temporary Seeding for Erosion Control: Refer to Civil Drawings.

1.3 REFERENCE STANDARDS:

A. The MDOT-SHA Standards and Specifications Manual, current edition.

B. The MDE Erosion and Sediment Control Handbook.

1.4 AREAS TO BE SODDED

A. All areas with slopes greater than 4:1. All areas between the Building and the first line of walkway or roadway around the Building perimeter, unless indicated otherwise on the drawings.

B. All other areas shall be seeded.

1.5 QUALITY ASSURANCE

A. All sod shall be transplanted within 24 hours from the time it is harvested, unless stacked at the project site in a manner approved by the Owner's Representative. Stacked sod shall be kept moist and protected from exposure to wind and sun. Any sod permitted to dry out shall be rejected.

B. Plant only during periods of favorable weather when conditions are suitable. Do not place sod at any time temperature is below freezing. No frozen sod shall be used, and no seed or sod shall be placed on frozen, powder-dry or excessively wet soil.

C. Seeding: Do not proceed with seed application before or after dates specified without written authorization from the Owner's Representative or Architect.

D. Soil amendments and rate of application shall be determined by laboratory test on soil.

1. Areas to be seeded or sodded shall have a soil pH range of 6.5 - 7.0. Contractor shall be responsible for ensuring correct soil pH.
2. Test pH level in at least five equidistant locations on the site. Review with the Owner's Representative or Architect who will determine whether the average soil pH value is within acceptable range. If existing soil pH is adequate, no soil amendments are required.

3. If average pH value is greater than 7.0, add a commercial grade sulfur at rate derived from lab test, over area to be seeded.
4. If average soil pH value is less than 6.5, then agricultural limestone shall be applied at rate derived from lab test.

1.6 SUBMITTALS

A. Submit statement of certification from local nursery from which sod shall be obtained.

B. Upon request, submit square yard of sod to project site for inspection by Architect and Owner's representative.

C. Submit certificates, signed by producer and contractor, stating that soil amendments, seed and sod comply with this specification. Certificates to include the following:

1. Limestone: Type, percentage of calcium magnesium carbonates or oxides, and gradation.
2. Fertilizer: Type and analysis.
3. Seed: Seed mixture percentages (variety and/or specie) germination percentage, weed seed percentage and seed test date.

D. Submit copy of laboratory test results and soil amendment recommendations for review by the Architect and the Owner's Representative.

E. Submit the name and qualifications of a Professional Lawn Care Firm to perform lawn maintenance during the maintenance period. The firm shall be one whose primary business is lawn care. The firm must be approved by the Owner prior to completion of sod installation.

F. Submit a proposed Lawn Maintenance Plan, detailing scheduled maintenance and compliance with the requirements of this specification. The plan shall include the name and location of the selected professional lawn care firm that will be performing the maintenance.

1.7 DELIVERY, STORAGE AND HANDLING

A. Seed: Deliver seed in original sealed, labeled and undamaged packaging.

B. Sod: Harvest, deliver, store and handle sod in compliance with the requirements of TPI's "Specifications for Turfgrass Sod Materials," and "Specifications for Turfgrass Sod Transplanting and Installation" contained in the "Guidelines Specifications to Turfgrass Sodding".

1.8 GUARANTEE, INSPECTION AND FINAL ACCEPTANCE

A. Guarantee that at end of ninety days after sodding, a healthy first class lawn shall exist.

B. Upon written request from Contractor, at least ten days before date of inspection, Owner or Architect will perform an inspection of seeded and sodded areas.

C. After inspection, list of deficiencies or omissions requiring correction will be proposed. Items shall be corrected and are subject to same guarantee and final inspection until found acceptable. Be responsible for continued maintenance of that portion of the lawn which, after ninety days, has not been accepted by Owner.

D. Not withstanding punch list items, Owner will certify in writing substantial completion of lawns and acceptance of work. Upon completion, reinspection of repairs or renewals necessary, Owner will assume responsibility for continued maintenance of lawn.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Topsoil shall be a natural, friable, granular soil containing organic matter, uniform composition and texture, and free from clay subsoil, stones, week plant root, sticks, gravel, trash or harmful chemicals. Obtain topsoil from project site stockpiles established during clearing operations, and amend as necessary. Obtain additional topsoil required for landscape development from off-site sources and transport to the project site at no increase to contract sum. Obtain approval from Architect to supply topsoil from more than one site. Do not excavate or haul topsoil when wet or frozen. All topsoil shall meet Maryland Erosion and Sediment Control Handbook requirements.

2.2 SOIL AMENDMENTS

A. Limestone: Agricultural grade limestone ground to such fineness that at least 10% passes a 100-mesh sieve, 50% passing a 40-mesh sieve, and at least 90% passes a 20-mesh sieve.

B. Sulfur: Commercial grade sulfur of equal grade, and quality as specified for limestone.

C. Gypsum: Agricultural grade gypsum ground to such fineness that at least 10% passes a 100-mesh sieve, 50% passing a 40-mesh sieve, and at least 90% passes a 20-mesh sieve.

2.3 FERTILIZER

A. Fertilizer: Complete organic or inorganic fertilizer with percentages of nitrogen, phosphoric acid, potash, and trace elements determined by the soil test. Fertilizer shall be delivered to the site in original unopened containers that bear manufacturer's guaranteed statement of analysis. Rate of application shall be determined by the soil test.

2.4 MULCHES

A. Straw Mulch: Air-dried, clean, mildew and seed free salt hay.

B. Fiber Mulch: Biodegradable, dyed wood, cellulose fiber mulch; non-toxic, free of plant growth or germination inhibitors; maximum moisture content 15%; pH range 4.5 to 6.5

C. Tackifier: Non-asphatic, colloidal tackifier, recommended by biber-mulch manufacturer for slurry application; non-toxic and free of plant growth or germination inhibitors.

2.5 SOD

A. State certified, nursery grown in nearby area, well rooted, free from disease, defects, insect infestation, or any unhealthy or abnormal condition, and free of weeds.

B. Sod Composition:
   1. General Site: Tall Fescue (Drought Tolerant, Full Sun Mixture)
      a. Certified Tall Fescue Cultivars, a mixture of at least two different types - 95%
      b. Certified Kentucky Bluegrass - 5%
   2. Ballfield Areas: Bermuda Grass Mix
      a. Bermudagrass (Cynodon Dactylon), varieties Tufcote or Vamont, 100%.

C. Submit statement giving locations of property from which sod is to be obtained and submit square yard sample of sod to site if requested.

2.6 SEED:

A. Seed shall be “Maryland Certified Seed", labeled in accordance with the State Seed Law. All seed used shall have been tested within the six months immediately preceding the date of sowing. The quality of the seed used shall be shown on the bag tags to conform to the specified guidelines. Purity and germination specified are minimum percentages by weight.
   1. Weed seed not to exceed 0.50 percent for each mixture. Noxious weed, including Johnson grass, Canada Thistle, Quackgrass and Poison Ivy are prohibited.

B. Seed Mixture:

Type	% by Weight	Min. % Purity	Min. % Germination
Tall Fescue:	80	95	85
(Provide a mixture of at least 3 separate types, "Rebel", "Gazelle”, “Falcon”, “Finelawn” or "Jaguar")			
Kentucky Bluegrass Improved	10	95	85
Perennial Ryegrass	10	95	85

   1. Substitutions of seed type or percentages will be allowed only upon approval of the Owner's Representative.

PART 3 - EXECUTION

3.1 FINISH GRADE

A. After rough grading has been completed and site cleared of construction debris, cover areas disturbed by construction or rough grade with minimum four inches of topsoil over earth to provide finish grade.

B. Final grades are indicated. Do not allow soil to pond. Firm topsoil by rolling to prevent washing and sinking. Degree of finish shall be that ordinarily obtained with blade grader or scraper. Finish surface to within 0.10 foot above or below established grade elevations indicated.

3.2 APPLICATION OF SOIL AMENDMENTS

A. If soil amendments are required, apply at rates specified. Bond topsoil mix to subgrade and mix soil amendments uniformly into topsoil by tilling, disking or harrowing to five inch depth. Adjacent to existing trees, adjust depth to avoid disturbances of tree roots.

3.3 FERTILIZING

A. Incorporate fertilizer with soil in same manner as lime, and apply and incorporate with soil simultaneous with liming operations. Type of fertilizer and rate of application shall be as specified.

3.4 SODDING

A. Sod shall be laid smooth, edge to edge, with staggered joints and immediately pressed firmly into contact with sod bed by rolling to eliminate air pockets. True and even surface shall be provided to ensure knitting without displacement of sod or deformation of surfaces of sodded areas. In ditches or swales, sod shall be placed with longer dimension perpendicular to flow of water in ditch.

B. Following compaction, screened topsoil of good quality shall be used to fill cracks, and excess soil worked into grass with rakes or other suitable equipment. Grass shall not be smothered with excess fill soil. Exposed edges of sod shall be buried flush with adjacent soil.

3.5 SEEDING

A. Slurry Preparation: Slurry mixture for 1000 gallon tank:

1. Seed Mixture: Set for minimum application rate of 350 pounds per acre or 75 pounds per tankful for lawns, 450 pounds per acre or 95 pounds per tankful for athletic field turf.
2. Fertilizer: 182 pounds.
3. Fiber Mulch: 310 pounds.
4. Binder Additive: 20 gallons.
5. Water: Fill tank.

B. Proportionally adjust mixture quantities for tanks of different capacities.

C. Slurry Application: Hydraulic application rate shall be 110 gallons per 1000 square feet. Application dates shall be 15 March to 15 May and 15 August to 31 October. Apply slurry mixture uniformly to prepared topsoil, in one continuous hydraulic operation. Do not begin hydraulic application until completion of topsoil preparation.

3.6 MAINTENANCE

A. Ensure the establishment of a healthy, first class lawn. Be responsible for all maintenance, protection, and repair until Owner accepts planted area. Include watering, rolling, fertilizing and mowing.

B. Maintenance shall be performed by a professional lawn care firm, whose primary business is lawn care. The Contractor shall submit the name of the lawn care firm to the Owner for approval.

C. Maintenance and protection of seeded and sodded areas shall continue until Owner accepts lawn. Barriers, sign, and/or flags shall be used on established pedestrian circulation ways as determined by Owner to indicate areas where trespassing is not allowed.

D. During the maintenance period repair or re-work washouts, dry areas, dead areas or erosion.

- END OF SECTION 32 93 05 -

SECTION 32 95 00
TREES, SHRUBS AND GROUND COVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 through Division 16 Specification Sections, apply to the Work of this Section.

1.2 RELATED WORK

A. Earthmoving: Section 31 20 00

B. Topsoiling, Seeding and Sodding: Refer to Civil Drawings and Section 32 93 05.

1.3 REFERENCE STANDARDS:

A. The MDOT-SHA Standards and Specifications Manual, current edition.

B. The MDE Erosion and Sediment Control Handbook, current edition.

1.4 JOB CONDITIONS

A. Prior to beginning work, the Contractor is required to schedule and attend an on-site meeting with the Owner, Architect, in order to verify site conditions and scope of work.

B. Proceed with and complete landscape work as rapidly as portions of site become available, working in cooperation with the construction manager and within seasonal limitations for each kind of landscape work required.

C. Utilities: Determine location of underground utilities and perform work in a manner that will avoid possible damage. Hand excavate, as required. Maintain grade stakes set by others until removal is authorized.

D. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify architect or Owner's Representative before planting.

E. Coordination with Lawns: Refer to Section 32 93 05. Plant trees and shrubs after final grades are established and prior to seeding and sodding. If planting of trees and shrubs occurs after seeding and sodding, protect lawn areas and promptly repair damage to lawns resulting from planting operations.

F. Extent of landscape development work is shown on drawings and in schedules and specified herein.

G. The work shall include, but not necessarily be limited to the following:
   1. Disposal of unused excavated material from planting excavations only.
   2. Furnishing, protecting and planting all trees and shrubs of types and sizes specified.
   3. Pruning, trimming, feeding, and mulching trees where trees are marked to be saved.
   4. Mulching new planting stock.
   5. Wrapping and staking new planting stock.
   6. Watering new planting stock.
   7. Furnishing and installing portable drip irrigation bags at each new tree.

8. Providing mulched areas for pedestrian walkways.
9. Providing timber edging along disturbed play areas and pedestrian walkways

H. Subgrade elevations: Excavation, filling and grading required to establish elevations shown on drawings are specified elsewhere. Refer to Earthmoving, Section 31 20 00.

1.5 QUALITY ASSURANCE

A. Subcontract landscape work to a single firm specializing in landscape work and with a record of satisfactory performance on similar projects.

B. Quality Control:

1. Comply with sizing and grading standards of the latest edition of "American Standard for Nursery Stock". A plant shall be dimensioned as it stands in its natural position.
2. All plants shall be nursery grown under climatic conditions similar to those in locality of the project for a minimum of 2 years.
3. Stock furnished shall be at least the minimum size indicated. Provide plants indicated with a measurement range so that only a maximum of 50 percent are of the minimum size indicated and 50 percent are of the maximum size indicated.
4. Plants will be inspected and approved at the place of installation, for compliance with specification requirements for quality, size and type of specimen.

1.6 DELIVERY, STORAGE AND HANDLING

A. Packaged Materials: Deliver materials in original packaging showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery and storage on site.

B. Trees and Shrubs: Provide freshly dug trees and shrubs. Do not prune prior to delivery. Do not bend or bind-tie trees or shrubs in such manner as to damage bark, break branches or destroy natural shape. Provide protective covering during delivery.

C. Deliver trees and shrubs after preparation for planting have been completed, and plant immediately. If planting is delayed more than 6 hours after delivery, set trees and shrubs in shade, protect from weather extremes and mechanical damage, and keep rootball moist.

1.7 SPECIAL PROJECT WARRANTY

A. It shall be the Contractor's responsibility to water, fertilize and otherwise maintain plant materials in healthy condition, free of stress and insect infestation, until such time as the landscaping is formally accepted in writing by the Owner. The two-year warranty shall not commence until such formal notice is given by the Inspector.

B. Warranty new trees and shrubs for a period of two years after date of Inspector's acceptance, against defects including death and unsatisfactory growth, except for defects resulting from neglect by Owner, abuse or damage by others, or unusual phenomena or incidents which are beyond Landscape Installer's control.

C. Remove and replace unsatisfactory trees or plants or those found to be dead or in unhealthy condition during warranty period. Make replacements during growth season following end of warranty period. Replace in kind and size specified and plant in accordance with this Section.

1.8 SUBMITTALS

A. Submit the name and qualifications of a Professional Landscape Firm to perform Landscape installations and plant maintenance during the maintenance period. The firm must be approved by the Owner prior to beginning landscape work.

B. Submit a proposed Planting Maintenance Plan, detailing scheduled maintenance and compliance with the requirements of this specification. The plan shall include the name and location of the selected professional Landscape firm that will be performing the maintenance.

C. Maintenance Instructions: Submit typewritten instructions to be used by Owner for maintenance of landscape work for one full year after termination of maintenance period. Submit prior to expiration of required maintenance period(s).

D. Submit manufacturer's catalog information and installation instructions for flexible plastic landscape edging and mulch for pedestrian walkways.

E. Submit manufacturer's catalog information and installation instructions for portable drip irrigation bags for new trees.

F. For products having regional material content, documentation indicating location of harvest of plants. Include statement indicating cost of each product with regional material content.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Topsoil stockpiled for re-use shall be used in areas receiving seed or sod. Topsoil for planting shall be supplied from off-site sources by this Contractor.

B. Provide new topsoil which is fertile, friable, natural loam, surface soil, reasonably free of subsoil, clay lumps, brush, weeds and other litter, and free of roots, stumps, stones larger than 2" in any dimension, and other extraneous or toxic matter harmful to plant growth. Determine pH of topsoil and add amendments as required.

C. Commercial Fertilizer: Complete fertilizer with some elements derived from organic sources and containing percentages of available plant nutrients recommended for each type of planting and of proper pH for each type of specimen (refer to Section 32 93 05).

2.2 PLANT MATERIALS

A. Plant materials shall be classified as per "American Standard for Nursery Stock", as adopted by the American Association of Nurserymen. Plant materials not meeting this standard shall be rejected.

1. Conform to requirements of the plant list.
2. All plant materials shall be nursery growth stock.
3. Trees shall be well branched, with full crown.
4. Each plant shall be free from disease, insect infestation, and dead branches.
5. Each plant shall be balled and burlapped (B&B), with rootball fully intact.
6. Substitutions may be made only after submission of evidence substantiating to the Architect's and Owner's satisfaction, non-availability of specified plant items and only if approved by the Architect.
7. Substitutions may be made only with Architect or Owner's approval, at same price as unavailable contract item or at lower, approved price with a credit provided.

B. Planting Soil Mix: 3 parts by volume topsoil, 1 part by volume peat moss.

C. Mulch: Shredded hardwood or pine bark.

D. Deciduous Tree Wrapping: Approved tree wrapping paper 4 inch width.

E. Stakes, guy wire and tubing: Of kind and size per drawings for proper support of specimen.

2.3 MULCH FOR PEDESTRIAN WALKWAYS

A. Provide treated wood mulch over the entire area indicated on the drawings, to a minimum depth of 6".

1. Acceptable ground covers: "Surflex", "Fibar", "Wood Carpet".

2.4 TIMBER EDGING

A. Timber shall be pressure treated for ground contact (0.40 #2 or better); recycled and/or creosoted timber shall not be acceptable.

1. All edges shall be 1/2" radius.
2. All lumber shall be free from splinters.
3. Two tiers of lumber shall be provided with rowlock or half-lapped joints. Bottom tier of lumber shall be set into the ground, and staked to the ground with steel rods reinforcing bars, 1/2" round, 36" on center, and 24" deep.
4. Top and bottom tiers shall be spiked together using galvanized fasteners.

2.5 FLEXIBLE PLASTIC EDGING

A. Edging shall be flexible high density polyethylene plastic, such as “Black Diamond Landscape Edging”, by Valley View Industries, 1-800-323-9369.

2.6 PORTABLE DRIP IRRIGATION BAGS

A. Portable drip irrigation bags shall be UV treated polyethylene bags, reinforced with nylon webbing, with nominal capacity of 20 gallons. Bags shall be designed to be connected together to form larger units for larger trees, if needed. Bags shall be designed to be easily filled with a standard garden hose, and to release water into the root ball of the tree over sufficient time to prevent runoff. Drip irrigation bags shall be “Treegator” bags, as manufactured by Spectrum Products, Inc., Raleigh, North Carolina, 1-866-treegator (web page treegator.com).

2.7 Provide plants harvested within 500-mile radius of Project Site.

PART 3 - EXECUTION

3.1 GENERAL

A. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations and outline areas and secure Architect's and Owner's acceptance before start of planting work. Make minor adjustments as may be requested.

B. Preparation for Planting:

1. Planting hole: Prepare in accordance with drawings and dispose of soil removed from hole.

2. Tree planting: Plants shall be set plumb, planted at same depth that plants grew in nursery.
3. After placing plant in hole, planting soil mix shall be gently but firmly tamped and sufficiently watered to ensure soil contact around all roots.
4. Earth saucers or water basins shall be at least four (4) inches deep with diameter equal to that of plant ball.
5. Water plants thoroughly during and immediately after planting.
6. Mulch to cover saucer area of individual plants.
7. Wrapping shall cover entire trunk to height of first branch.
8. Guy with stake locations and depth per drawings, with a minimum of three stakes per tree.
9. Prune shortly after planting only when deemed necessary by Architect or Owner's Representative to remove broken and bruised branches.
10. Provide and install portable drip irrigation bags at each new tree. Provide single unit bags (20 gallons) for trees with 1” to 4” trunks, and combine bags to form a 50 gallon set for trees with 4” to 8” trunks. Install in accordance with manufacturer’s instructions. Fill the bags and begin scheduled maintenance.

3.2 MULCH WALKWAYS

A. Prior to installing mulch, treat the existing surface to be covered with a contact herbicide such as “Roundup” to kill all existing vegetation under the mulch. Then apply a pre-emergent herbicide to the area to be mulched.

B. Cover the area to be mulched with a layer of filter cloth prior to installing mulch cover. Key the edges of the filter cloth layer a minimum of 6 inches down into the soil with the plastic edging, or pin the edges under the timber edging for timber edged walkways.

C. Cover the area to be mulched with a minimum tamped thickness of six inches of treated wood mulch.

3.3 EDGING

A. Install flexible plastic landscape edging in accordance with manufacturer’s instructions. Leave enough edging exposed above grade to contain mulch. Install flexible plastic edging and timber edging where indicated on the Drawings.

3.4 CLEANUP AND PROTECTION

A. During landscape work, keep adjacent paved areas clean, and work area in an orderly condition.

B. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.

3.5 MAINTENANCE

A. Contractor shall maintain all plants in a healthy condition. Contractor's maintenance responsibilities shall consist of pruning, watering, fertilizing, cultivating, weeding, mulching, tightening and repairing of staking, setting plants to proper grades or upright position, restoration of the planting saucer, and furnishing and applying sprays or other items as are necessary to keep the planting free of insects and disease and in thriving condition. Maintenance shall be performed by a professional Landscaping firm, whose primary business is landscaping and plant care.

B. Maintenance shall begin immediately after each plant is planted and shall continue for a period of 60 days from the date of acceptance by the Owner.

3.6 INSPECTION AND ACCEPTANCE

A. When landscape work described in this section is completed, the Architect and Owner's Representative will make an inspection to determine acceptability.

B. Where inspected landscape work does not comply with requirements, replace rejected work and continue specified maintenance until reinspected by Architect and Owner's representative and found to be acceptable. Remove rejected plants and materials from project site, and replace with healthy specimens.

C. It shall be the Contractor's responsibility to diligently pursue approval of the landscaping from Frederick County, and to correct punch list inspection items, prior to Owners occupancy of the new construction.

- END OF SECTION 32 95 00 -

SECTION 33 10 00
UTILITY STANDARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials, work and standards for site and utility construction materials and work.

1.3 RELATED WORK

A. Refer to Section 31 20 00 "Earthmoving"; Section 33 41 00 "Storm Drainage", Division 22 "Plumbing" and Division 26 "Electrical".

1.4 STANDARDS

A. Maryland Department of Transportation State Highway Administration current “Standard Specifications for Construction and Materials”, Measurement and Payment Clauses do not apply.

B. American Concrete Institute (ACI).

1.5 SUBMITTALS

A. Products:

1. Submit typewritten list of selected products, when options are specified, within 10 calendar days after contract execution. Submit detailed shop drawings of utility modifications required by selection of options.
2. Submit manufacturer's descriptive literature of structure castings.
3. Submit Portland cement concrete mix design formula for each class specified.
4. Submit certificates, signed by manufacturer or producer and contractor, stating the following comply with this specification:
   a. Portland cement.
   b. Fine aggregates.
   c. Coarse aggregates.
   d. Portland cement concrete.
   e. Concrete masonry units.
   f. Brick.
   g. Foundation materials.
   h. Bedding materials.
5. Submit shop drawings, of the following, indicating concrete reinforcement locations, size and placement:
   a. Cast in place reinforced concrete structures.
   b. Pre-cast reinforced concrete structures.
6. Submit location of product manufacture and of extraction/recovery of primary raw materials.

B. Compaction Equipment: Submit compaction equipment data prior to start of controlled fill earthwork operations.

C. Testing: Submit test reports of testing specified.

D. “As-Built” Plans: Submit “as-built” plans for water, sanitary sewer and storm drainage systems. Submit to the Owner’s Representative and to controlling utility agencies as required.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Delivery: Schedule delivery operations to avoid unnecessary re-handling.

B. Storage:

1. General: Store in accordance with manufacturer's recommendations and as noted.

2. Portland cement: Store on platforms above ground and protect from adverse environmental conditions.

3. Aggregates: Store to prevent foreign material contamination.

4. Utility Joint Materials and Lubricants: Store in cool and dry location free of oil, grease, excessive heat and direct sunrays.

C. Handling:

1. General: Comply with manufacturer's recommendations and as noted.

2. Aggregates: Handle to prevent segregation.

3. Pre-cast Concrete Structures: Handle to prevent damage. Utilize lifting holes provided by structure manufacturer.

1.7 DEFINITIONS

A. Refer to Section 31 20 00 "Earthmoving".

1.8 PROJECT CONDITIONS

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Traffic: Maintain pedestrian and vehicular traffic during utility construction operations.

C. Limitations:

1. Environmental: Do not place Portland cement products or erect masonry when ambient air temperature is below 40 degrees Fahrenheit or air temperature has been below 35 degrees Fahrenheit for twelve or more consecutive hours or between 15 November and 1 March without written authorization from the Owner’s Representative or the Architect.

D. Certifications, Inspections and As-Built Documents

1. The Contractor shall provide inspection, certification and "as-built" plans of the on-site water, sanitary sewer service and storm sewer work by a locally registered professional Engineer. Contractor shall notify the Architect within 15 calendar days of signing the contract who the Registered P.E. will be and who will certify the as-built water and sewer plan. Show any changes and include ties for the location of valves, bends, manholes, fire hydrants, and laterals accompanied by the qualifying air test date and certification of compliance. See Division One “Project Record Documents” for format of “as-built” drawings.

2. All storm drain system work must be inspected by Frederick County in accordance with agency permit requirements. Record of as-built conditions will be required.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement Concrete: SHA Section 902, Portland Cement Concrete and Related Products.

1. Water: Clean and free of oil, acid and injurious amounts of vegetable matter, alkalis and salts. River, stream or lake water is prohibited.
2. Forms: Wood, steel or as specified. Form materials to produce smooth surfaces, free of irregularities. Nonrented wood formwork shall be made of FSC-certified sustainably harvested wood materials.

B. Mixes

1. Class "A" Concrete: SHA Mix No. 4, Table 902 A. 28-Day compressive strength 3500 P.S.I. Maximum 50% GGBF slag replacement for Portland cement, per MDOT-SHA Specification 902.06.05.

2. Class "B" Concrete: SHA Mix No. 2, Table 902 A. 28-Day compressive strength 3000 P.S.I. Maximum 50% GGBF slag replacement for Portland cement, per MDOT-SHA Specification 902.06.05.

C. Concrete Reinforcements

1. Steel bars: ASTM A 615, Grade 60, deformed, designation as indicated or specified. Minimum 99% recycled-content, of which minimum 60% shall be post-consumer and the remainder may be post-industrial material.

2. Steel Wire Mesh: ASTM A 185 welded wire mesh, roll type, size as indicated or specified.

D. Brick:

1. Type A: ASTM C 55 Concrete Building Brick, type I, grade N, standard manufacture size.

2. Type B: ASTM C 32 Clay or Shale Brick, grade SS or as specified, solid, 2-1/4 by 3-3/4 by 8 inches.

E. Cement Mortar: MDOT-SHA Section 902.05, Masonry Cement.

1. Water: As specified for Portland cement concrete.

F. Cast-in-Place Reinforced Concrete Structures

1. Structure Bases: Class "B" Portland Cement Concrete.
2. Structure Walls and Top Slabs: Class "A" Portland Cement Concrete.
3. Concrete Reinforcement, Structural Steel, Structure Castings and Appurtenances: As indicated and specified.

G. Pre-Cast Reinforced Concrete Structures

1. Square and Rectangular Structures: ASTM C 858.

2. Structural Design Loading: ASTM C 858, live load designation A-16.

3. Circular Structures: ASTM C 478.

4. Structure Joints: ASTM C 443.

H. Foundation Materials:

1. Type I: ASTM C 33 Coarse Aggregate, size No. 8 (3/8 inch to No. 8).

2. Type II: MDOT-SHA Coarse Aggregate Size No. 57 stone (1 1/2 inch to No. 8).

3. Type III: Material free of debris, waste materials, frozen materials, vegetable matter, clay, rocks or stones exceeding 1 inch in any dimension. Obtain Type III material from on-site excavations or off-site borrow areas approved by the Soils Engineer.

I. Bedding Materials:

1. Type A: ASTM C 33 Fine Aggregate.

2. Type B: ASTM C 33 Coarse Aggregate, size No. 6 (1 inch to No. 4).
   a. Contractor's Option: SHA Coarse Aggregate Size No. 57 stone (1 1/2 to No. 8.)

3. Type C: Earth material free of debris, waste materials, frozen materials, vegetable matter, clay and rocks or stones exceeding one inch in any direction.

J. Bedding Material Schedule:

1. Storm drainage system: Type B, or as per manufacturers recommendations.

2. Water Distribution System: Frederick County Standards, or Type A.

3. Sanitary Sewer System: Frederick County Standards, or Type B.

4. All other utilities: Type C.

K. Backfill Materials: As specified for Fill or Backfill, Section 31 20 00 "Earthmoving", and as noted.

1. Utility Trenches
   a. Phase I: Earth material free of debris, waste materials, frozen materials, vegetable matter and rock or stones exceeding one inch in any dimension.
   b. Phase II: Earth material free of debris, waste material, frozen material, vegetable matter and rock or stones exceeding two inches in any dimension.
2. Utility Structures: Earth material free of debris, waste material, frozen material, vegetable matter and rock or stones exceeding two inches in any dimension. Obtain backfill material from the following: Excavated material approved by the Soils Engineer or the Owner's Representative.

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. General: Provide support systems (e.g. sheeting, shoring, sheet piling, cribbing, etc.) at no increase to contract sum. Cut off timber when using timber support systems above top of utility to prevent utility displacement. Exercise care when using trench shields or boxes during shield movement to prevent utility displacement.

3.2 EXISTING UTILITIES:

A. Refer to Section 31 20 00 "Earthmoving", and as noted. Contractor shall notify "Miss Utility" at least 48 hours prior to start of construction.

B. Provide test pits at all existing utility crossings prior to any system construction. Verify utility inverts for review by Architect or the Owner's Representative to determine potential conflicts prior to start of system construction.

3.3 DEWATERING:

A. Refer to Section 31 20 00 "Earthmoving".

3.4 EXCAVATION:

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Trench Excavation: Open cut method or as specified. Excavate materials encountered to subgrade elevations indicated or specified.

1. Trench width below top of utility not to exceed the following clearances on each side of utility:
2. Utility Exterior Width, Diameter or Span — Clearance

Utility Exterior Width, Diameter or Span	Clearance
1 thru 30 in.	16 in.
31 and higher	24 in.

3. Excavate utility trenches to the following depths:
   a. Circular storm drainage pipe: Six inches below bottom of pipe.
   b. Water distribution pipe: Frederick County Standards or four inches below bottom of pipe.
   c. Sanitary sewer pipe: Frederick County Standards or six inches below bottom of pipe.
   d. All other utilities: Bottom of utility.

C. Structure Excavation:

1. Utility structure excavation to produce 12-inch clearance between exterior structure walls and excavation walls or support systems.

2. Extend excavation to the following:
   a. Cast in place reinforced concrete structures: Six inches beyond structure base.
   b. Pre-cast reinforced concrete structures: Six inches below bottom of pre-cast structure base.
   c. Pre-cast reinforced concrete structure with cast in place concrete base: Bottom of structure base.
   d. Masonry structures: Bottom of structure base.

3.5 OVER-EXCAVATION:

A. Refer to Section 31 20 00 "Earthmoving", except as noted.

B. Utility Trenches:

1. Correct over-excavation of water distribution, storm drainage and gravity flow sanitary sewer systems by backfilling over-excavated trenches with Type II foundation (Type B bedding) material and compacting.

2. Correct over-excavation of all other utilities by backfilling over-excavated trenches with Type III foundation (Type C bedding) material and compacting.

3. Place material in loose lifts not exceeding eight inches. Compact each lift to 95 percent maximum dry density. Density test method: ASTM D 698.

C. Structures: Correct utility structure over-excavation by backfilling over-excavation with Type II foundation (Type B bedding) material and compacting.

1. Place material in loose lifts not exceeding eight inches. Compact each lift to 95 percent maximum dry density. Density test method: ASTM D 698.

3.6 UNSUITABLE EARTH

A. Refer to Section 31 20 00 "Earthmoving", except as noted.

B. Restore unsuitable earth excavation as specified for over-excavation.

3.7 EXCAVATED MATERIAL STORAGE

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Stockpile select excavated materials required for backfill operations.

3.8 PORTLAND CEMENT CONCRETE CONSTRUCTION:

A. Mixing

1. Ready-Mixed Concrete: ASTM C 94.
2. Project Site Batch Mixing: ACI 301, Chapter 7.

B. Formwork: ACI 301, Chapter 4.

C. Reinforcement: ACI 301, Chapter 5.

D. Joints and Embedded Items: ACI 301, Chapter 6.

E. Placement: ACI 301, Chapter 8.

F. Surface Defects: ACI 301, Chapter 9.

G. Finishes: ACI 301. Non-Exposed: Section 10.2.1. Exposed: Section 10.2.2.

H. Curing and Protection: ACI 301, Chapter 12.

I. Cold Weather Concreting: ACI 306R.

J. Hot Weather Concreting: ACI 305R.

3.9 STRUCTURES

A. Cast in Place Reinforced Concrete Structures: Construct cast in place concrete structures as indicated and specified.

B. Pre-cast Reinforced Concrete Structures:

1. Pre-cast structure base: Place Type I foundation material, on excavation subgrade, to bottom of structure base and compact to 95 percent of maximum dry density by ASTM D 698. Install pre-cast structure base, on compacted foundation material, level to 1/8 inch in 5 feet. Clean and lubricate structure joints, immediately prior to installation, in accordance with manufacturer's recommendation. Install pre-cast reinforced structure sections, on structure base, plumb to 1/4 inch in 10 feet. Position structure sections on previously installed section and push joints tightly together. Position concrete top slabs on structure as indicated. Plug lifting holes with cement mortar. Install frames and covers to finished grade with bricks and cement mortar.

C. Masonry Structures

1. Erect structure walls with masonry materials specified. Wet each masonry unit thoroughly before placement. Shove each unit into place in full bed of cement mortar. Horizontal and vertical joints not to exceed 1/2 inch.
2. Bond and Coursing: Brick Masonry - Common Bond.
3. Fill joints completely with cement mortar. Fit masonry units tightly around utilities projecting through structure walls. Space, set and bond structure appurtenances as indicated or specified during masonry erection. Point up interior structure joints and clean removing excess cement mortar. Parge exterior structure walls with 1/2 inch thick cement mortar and finish with smooth trowel. Masonry construction tolerances not to exceed 1/4 inch in 10 feet vertical from plumb.

3.10 BEDDING

A. Storm drainage pipe: Place bedding material, on excavated trench subgrade to bottom of pipe and compact. Upon completion of pipe installation, place and compact bedding material to pipe springline.

B. All Other Utilities: Bedding not required. Install utilities on excavated trench subgrade as indicated or specified by Frederick County.

3.11 BACKFILL

A. Backfill utility trenches in two consecutive phases as follows

1. Phase I - Backfill to 12-inch depth above top of utility. Place backfill material in loose lifts not exceeding four (4) inches. Compact each lift to 95 percent maximum dry density. Density test method: ASTM D 698.

2. Phase II - Unpaved Areas: Place backfill material to grade in loose lifts not exceeding eight (8) inches. Compact each lift to 90 percent maximum dry density. Density test method: ASTM D 698

3. Phase II - Paved Areas: Place backfill material to grade in loose lifts not exceeding eight (8) inches. Compact each lift to 95 percent maximum dry density. Density test method: ASTM D 698.

B. Backfill utility structures as follows: Place backfill material carefully and in loose lifts not exceeding eight (8) inches in depth. Compact each lift to 95 percent maximum dry density. Density test method: ASTM D 698. Do not backfill masonry structures until cement mortar parge attains initial set.

3.12 EXCAVATED MATERIAL DISPOSAL

A. Refer to Section 31 20 00 "Earthmoving".

- END OF SECTION 33 10 00 -

SECTION 33 10 05
WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to construct water distribution system.

1.3 RELATED WORK

A. Refer to Section 33 10 00 "Utility Standards".

1.4 STANDARDS

A. Frederick County's current "General Conditions and Standard Specifications" and "Standard Details".

B. American Water Works Association (AWWA).

1.5 SUBMITTALS

A. Refer to Section 33 10 00 "Utility Standards" and as noted.

B. Products: Submit product manufacturer's specifications and installation instructions and certificates of compliance signed by manufacturer and contractor stating that products comply with this specification to the Architect. Certificates of compliance must be notarized, signed by an officer of the Manufacturer, and shall include job location, Contractor's name, types, classes and strengths of pipe and fittings, and the Manufacturer's name.

C. Submit As-built drawings to the Architect.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Refer to Section 33 10 00 "Utility Standards", and as noted.

1.7 PROJECT CONDITIONS

A. Refer to Section 33 10 00 "Utility Standards", and as noted.
B. All on-site construction and materials shall be in accordance with the latest edition of the Frederick County General Conditions and Standard Specifications, Design Manual, and Standard Details

1.8 CONSTRUCTION SURVEYS

A. Provide survey equipment and qualified personnel for construction surveys. Provide combined horizontal and vertical alignment stakes for system construction. Horizontal stake interval to be 50 feet and at all appurtenances (e.g. fittings, valves, etc.). Provide construction cut sheet preparation as required.

1.9 SPECIAL INSPECTIONS, TESTING OBSERVATION AND CERTIFICATIONS

A. ADDITIONAL INSPECTIONS, OBSERVATIONS AND CERTIFICATIONS: It shall be the responsibility of the contractor to hire the Engineer-of-Record to perform any additional special inspections, testing observations and certifications required beyond those specific services identified herein as being provided by the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials shall be Frederick County Standards and shall meet all Frederick County requirements indicated.

B. Valve Boxes: Cast iron two-piece valve boxes, screw type box, bell base section, 5-1/4 inch shaft, round drop cover with "W" marking.

2.2 CONCRETE PADS: Class 'A' Portland cement.

2.3 CONCRETE ANCHORS: Frederick County Standards indicated and specified. Class 'A' Portland cement concrete, Section 33 10 00 "Utility Standards".

2.4 STRAPS AND RODS

A. Clamps, Straps and Washers: Steel, ASTM A 506.

B. Rods: Steel, ASTM A 575.

C. Rod Couplings: Malleable-Iron, ASTM A 197

D. Bolts: Steel, ASTM A 307

E. Cast-Iron Washers: Gray-iron, ASTM A 126

2.5 MISCELLANEOUS PRODUCTS

A. Underground Identification Tape: Manufactured by Allen Systems, Houston, Texas.

1. Type: “Markline”.
2. Color: Precaution Blue.
3. Legend: Caution water line buried below.
4. Tape Width: Three inches.

B. Disinfection Products: Frederick County standards indicated and specified. For continuous feed disinfection method, use Calcium Hypochlorite: AWWA B 300, granular form.

1. Contractor's Option: AWWA B 301 Liquid Chlorine.
2. Contractor's Option: AWWA B 303 Sodium Chloride.
3. Water: Potable.

PART 3 - EXECUTION

3.1 PROTECTION AND RESTORATION

A. Refer to Section 33 10 00 "Utility Standards".

3.2 DEWATERING, EXCAVATION, OVER-EXCAVATION AND UNSUITABLE EARTH:

A. Refer to Section 33 10 00 "Utility Standards".

3.3 PIPE

A. General

1. Install in accordance with pipe manufacturer's installation instructions, Frederick County standards and requirements and as noted.

2. Inspect each pipe laying length, pipe joint materials and fittings for defects. Remove defective products from project site. Install pipe to horizontal and vertical alignment indicated. Place fittings at changes in horizontal and vertical alignment as indicated. Construct concrete anchors at each fitting as indicated. Place concrete to permit access to joints for inspection and maintenance. Apply liberal coat of coal tar pitch to exposed steel and hardware. Field cut pipe only where required to complete closures or to install fittings, valves or fire protection equipment. Cut pipe to smooth square end with equipment designed for cutting pipe.

B. Ductile Iron Pipe:

1. Install pipe in accordance with AWWA C 600 and as noted.

2. Install with bell ends facing in direction of laying operations. Begin installation of pipe, with vertical gradient exceeding 10 percent, at lowest elevation and proceed upgrade. Place identifying mark on pipe not provided with spigot depth mark. Clean interior and exterior surfaces of bell and spigot removing oil, grit, excess coating and foreign matter. Lubricate pipe ends and gasket in accordance with pipe manufacturer's instruction.

C. Ductile Iron Push-On Pipe: Position each laying length in previously installed pipe and push or pull joint tightly together with mechanical device designed for pipe jointing. Grind or file spigot end of field cut pipe to resemble manufactured spigot end. Place spigot identifying depth mark as specified. Pipe joint deflection not to exceed the limits specified in Table 2, AWWA C 655.

3.4 BURIED VALVES

A. Install valves in accordance with valve manufacturer's installation instructions, and Frederick County requirements.

3.5 FIRE HYDRANTS

A. General: Install fire hydrants at locations indicated, in accordance with AWWA M17 "Installation, Operation and Maintenance of Fire Hydrants", manufacturer's installation instructions, and Frederick County standards and requirements.

3.6 BACKFILL

A. Refer to Section 33 10 00 "Utility Standards" and as noted.

B. Valve Box Installation: Install valve box for each buried gate valve during backfill operations. Install boxes to prevent shock or stress transmission to valves or pipe and center over valve operating nut plumb to 1/4 inch in five feet. Adjust box cover flush to finished grade.

C. Underground Identification Tape: Install tape during backfill operations. Tape shall be centered over pipe, located 24 inches below finished grade.

3.7 SYSTEM TESTING

A. General: Provide materials, equipment (e.g. pumps, gauges, etc.) and labor required to test system. Do not conduct tests until concrete anchors cure and set seven calendar days. Provide a minimum of 48 hours notification of planned testing. Test observation by the Architect and local governing water authority personnel. Test system in accordance with AWWA C 600 and as noted.

B. Hydrostatic Pressure Tests: Conduct hydrostatic pressure tests, upon completion of Phase I backfill operations. Fill systems or valved section of system with water. Expel air from pipe. Slowly apply test pressure. Test pressure to be 200 PSI. Test duration to be two hours. Test pressure shall not vary more than +5 psi for the duration of the test. Examine all system joints. Correct defective products or improper system installation as directed by the Architect and local governing water authority personnel.

C. Hydrostatic Leakage Tests: Conduct hydrostatic leakage tests upon completion of Phase II backfill operations. Test procedure as specified for hydrostatic pressure tests, except as noted. Test pressure @ 110 PSI. Test duration 24 hours. Allowable leakage for ductile iron pipe is not to exceed the limits specified in Table 3, AWWA C 600. Correct system installation exceeding allowable leakage specified as directed by the Architect and local governing water authority personnel.

3.8 INSPECTION AND CERTIFICATION

A. Retain the services of a Maryland-registered engineer for inspection of system construction and certification that system complies with standards specified. In accordance with the requirements on the approved drawings, the inspecting engineer must be the engineer of record for the approved drawings.

3.9 SYSTEM DISINFECTION

A. Disinfect system in accordance with AWWA C 651, Frederick County standards specified, and as noted. Provide materials, equipment (e.g. pumps, etc.) and labor required to disinfect system.

B. Disinfection Method: Continuous feed.

1. Preliminary and final flushing velocity to be 2.5 fps. Solution concentration as specified. Maintain 50 MG/L available chlorine during 24-hour disinfection period. Bacteriologic test interval every six hours. Flushing and drainage locations where directed by the Owner's Representative.

3.10 DISINFECTION TESTING

A. Conduct chlorine residual tests upon completion of final flushing operations. Repeat disinfection operation until satisfactory chlorine residual quality tests are obtained.

3.11 WATER BACTERIOLOGIC QUALITY TESTING

A. Retain the services of an independent testing laboratory to conduct water bacteriologic quality testing.

- END OF SECTION 33 10 05 -

SECTION 33 30 00
SANITARY SEWERAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to construct gravity flow sanitary sewer system.

1.3 RELATED WORK

A. Refer to Section 31 20 00 "Earthmoving", Section 33 10 00 "Utility Standards", Section 33 41 00 "Storm Drainage", and Division 22 "Plumbing".

1.4 STANDARDS

A. Refer to Section 33 10 00 "Utility Standards", and as noted.

B. Frederick County current "General Conditions and Standard Specifications" and "Standard Details".

1.5 SUBMITTALS

A. Refer to Section 33 10 00 "Utility Standards" and as noted.

B. Products: Submit product manufacturer's specifications and installation instructions and certificates of compliance signed by manufacturer and contractor stating that products comply with this specification to the Architect. Certificates of compliance must be notarized, signed by an officer of the Manufacturer, and shall include job location, Contractor’s name, types, classes and strengths of pipe and fittings, and the Manufacturer’s name.

C. Options: Submit typewritten list of selected products when options are specified within 10 calendar days after contract execution. Submit detailed shop drawings of system modifications required by selection of options.

D. Submit shop drawings of precast structures indicating concrete reinforcement location, size and placement.

E. Submit As-built drawings to the Architect.

1.6 PRODUCT, DELIVERY, STORAGE AND HANDLING

A. Refer to Section 33 10 00 "Utility Standards".

1.7 PROJECT CONDITIONS

A. Refer to Section 33 10 00 "Utility Standards" and as noted.

B. All on-site construction and materials shall be in accordance with the latest edition of the Frederick County General Conditions and Standard Specifications, Design Manual, and

Standard Details.

C. Existing Sanitary Sewer System: Provide, install, operate and maintain pumps and related equipment required to divert sewage (bypass pumping) during system construction. Extend pump discharge lines to existing sanitary sewer structures. Surface flow is prohibited.

D. Traffic: Maintain vehicular and pedestrian traffic during system construction.

1.8 CONSTRUCTION SURVEYS

A. Provide survey equipment and qualified personnel for construction surveys. Provide combined horizontal and vertical alignment stakes for system construction. Horizontal stake interval to be 25 feet maximum and at all structures. Provide construction cut sheet preparation as required.

1.9 SPECIAL INSPECTIONS, TESTING OBSERVATION AND CERTIFICATIONS

A. ADDITIONAL INSPECTIONS, OBSERVATIONS AND CERTIFICATIONS: It shall be the responsibility of the contractor to hire the Engineer-of-Record to perform any additional special inspections, testing observations and certifications required beyond those specific services identified herein as being provided by the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials shall be Frederick County Standards and shall meet all Frederick County requirements indicated.

B. Polyvinyl Chloride (PVC) Pipe: ASTM D 3034, SDR 35 PVC gravity sewer pipe, size as indicated, standard manufacture laying length.
   1. Pipe Joints: ASTM D 3212 bell and spigot type, with flexible elastomeric gasket seals. Gaskets shall meet the requirements of ASTM F 477.
   2. Fittings shall be as indicated and required.

C. Cleanouts:
   1. Cleanouts For Use in Paved Walk Areas: Refer to Section 33 41 00 "Storm Drainage", and as noted.
      a. Expansion Joint: ASTM D 994, bituminous preformed joint filler, 1/2 inch thick.

   2. Furnish the owner with one cleanout wrench.

D. Structures: Frederick County standards specified and indicated.

E. Foundation and Bedding Materials: Refer to Section 33 10 00 "Utility Standards".

F. Concrete: Refer to Section 33 10 00 "Utility Standards".

G. Miscellaneous Products:
   1. Underground identification type manufactured by Allen Systems, Houston, Texas. "Detectatape" type, three inches wide, marked "Caution Sewer Line Buried Below", "Safety Green" color.

PART 3 - EXECUTION

3.1 DEWATERING, EXCAVATION, OVER-EXCAVATION AND UNSUITABLE EARTH:

A. Refer to Section 33 10 00 "Utility Standards".

3.2 EXISTING SYSTEM CONNECTION

A. Notify Frederick County no less than 48 hours prior to the start of system construction.

B. Excavate and expose existing pipe at connection location indicated. Adjust connection location, as required, in the event of conflicts with existing pipe joints. Neatly cut existing pipe and prepare cut end as required for connection with new pipe. Make connections with existing pipe using fittings designed for the purpose, in accordance with manufacturer's installation instructions.

3.3 PIPE

A. General: Install in accordance with manufacturer's installation instructions and as noted. Inspect each pipe laying length and pipe joint materials for defects. Remove defective products from project site. Install pipe to horizontal and vertical alignment indicated. Begin with installation at lowest system elevation and proceed up-grade. Field cut pipe only where required to complete structure-to-structure closures, install fittings or as specified. Cut pipe to smooth square end with equipment designed for cutting pipe.

B. Polyvinyl Chloride (PVC) Pipe: Install pipe in accordance with ASTM D 2321, manufacturer's installation instructions, and as noted.
   1. Install with pipe spigot end pointing in flow direction. Begin installation of pipe, with vertical gradient exceeding 10 percent, at lowest elevation and proceed up-grade. Clean bell and spigot interior and exterior surfaces, removing oil, grit and foreign matter. Lubricate pipe ends and gasket in accordance with manufacturer's instructions. Position each laying length of previously installed pipe and manually push joint tightly together.

   2. Field Pipe Cutting: Shape spigot end of cut pipe to resemble manufactured spigot end, with a pipe-beveling tool designed for PVC pipe. Copy the full insertion mark provided on the manufactured spigot end onto the prepared field cut end.

3.4 EXISTING PIPE/STRUCTURE CONSTRUCTION

A. Excavate and expose existing pipe at structure location indicated. Adjust structure location as directed by the Architect or Owner's Representative in the event existing pipe joint interferes with structure walls, or as required to obtain required invert, at no increase to contract sum. Manually excavate below existing pipe prior to structure base placement. Place concrete structure base and construct structure as specified. Neatly cut and remove upper half of existing pipe and construct invert flow channel.

3.5 STRUCTURES

A. Refer to Section 33 10 00 "Utility Standards" and as noted.

B. Pipe Connections: Install pipe opening sleeves in accordance with manufacturer's installation instructions. Neatly cut pipes flush with interior structure walls except as otherwise indicated or specified.

C. Structure Joints: Apply liberal coat of joint coating material to each structure section joint in accordance with manufacturer's application instructions.

D. Invert Flow Channels: Construct invert flow channels smooth and semicircular in shape. Shape channels with horizontal circular curve radii as large as structure will permit. Neatly

form channels in structure base with bricks and cement mortar.

3.6 CLEANOUTS

A. Refer to Section 33 41 00 "Storm Drainage", and as noted.

B. Install cleanouts in accordance with manufacturer's installation instructions and as indicated.
   1. Construct concrete pads of Class "A" concrete as indicated.
   2. Cleanouts in paved walk shall be installed without a concrete pad. Top shall be cast into and set flush with finished walk surface.

3.7 BACKFILL

A. Refer to Section 33 10 00 "Utility Standards", and as noted.

B. Sanitary Sewer mains must be inspected by the Architect and Frederick County prior to completion of backfill operations. Contractor shall provide a minimum of 48 hours notice before completion of backfill operations.

C. Underground Identification Tape: Install tape during backfill operations. Tape shall be centered over pipe, located 12 inches above top of pipe.

3.8 SYSTEM TESTING

A. Provide equipment, materials and labor required to test system. Conduct low pressure air tests in accordance with local jurisdiction approving agency standards. Provide a minimum of 48 hours notification of planned testing. Test observation by the Architect and Frederick County.

B. Repair or replace defective products and system construction, which fails tests as directed by local jurisdiction approving agency. Provide additional corrective work and retesting until system is approved and accepted. Provide corrective work and retesting at no increase to contract sum.

3.9 SYSTEM INSPECTION

A. Retain the services of a Maryland-registered engineer for inspection of system construction and certification that system complies with standards specified. In accordance with the requirements on the approved drawings, the inspecting engineer must be the engineer of record for the approved drawings.

B. Provide additional corrective work, determined necessary by television inspection, as specified for system testing.

- END OF SECTION 33 30 00 -

SECTION 33 41 00
STORM DRAINAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. This section specifies materials and work required to construct storm drainage system.

1.3 RELATED WORK

A. Refer to Section 31 10 00 "Clearing", Section 31 20 00 "Earthmoving", Section 33 10 00 "Utility Standards"; Section 32 13 13 "Concrete Paving" and Division 22 "Plumbing".

1.4 STANDARDS

A. Frederick County Department of Transportation current "Design Standards".

B. Maryland Department of Transportation State Highway Administration current "Standard Specifications for Construction and Materials".

C. Maryland Standards and Specifications for Soil Erosion and Sediment Control, current edition.

D. American Concrete Pipe Association (ACPA).

E. Cast Iron Soil Pipe Institute (CISPI).

1.5 SUBMITTALS

A. Products:
   1. Submit certificate signed by manufacturer and contractor stating that pipe and pipe joint materials comply with this specification.
   2. Submit shop drawings of pre-cast reinforced structures and cast in place reinforced concrete structures indicating location, size and placement of concrete reinforcement.
   3. Submit manufacturer's descriptive literature of cleanouts.
   4. Submit location of product manufacture.
   5. Special shop drawing and submittal reviews are those requiring third-party (governing agency) review and approval in addition to normal reviews by the Owner, the Architect and/or the Engineer of Record. In instances where shop drawings and contractors submittals must also be reviewed and approved by municipal agencies or other entities, the normal review turnaround time shall be extended by the Contractor as required to accommodate these reviews and approvals at no additional cost or delay to the Owner, the Architect and/or the Engineer of Record. The contractor shall schedule and/or adjust work schedules accordingly.
   6. The contractor shall bear all surveying, engineering and permitting costs for re-design and/or re-engineering required for substitutions and/or to expedite construction and/or accommodate changes in the contractor’s construction methods and means.

1.6 PROJECT CONDITIONS

A. Refer to Section 31 20 00 "Earthmoving" and as noted.

B. Existing Storm Drainage System: Provide, install, operate and maintain pumps and related equipment required to divert storm water during system construction.

C. Traffic: Maintain pedestrian and vehicular traffic during system construction.

D. As-Built Documents:
   1. Refer to Section 33 10 00 “Utility Standards

1.7 CONSTRUCTION SURVEYS:

A. Provide survey equipment and qualified personnel for construction surveys. Provide combined horizontal and vertical alignment stakes for system construction. Horizontal stake interval to be 25 feet maximum and at all structures. Provide construction cut sheet preparation as required.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide products manufactured within a 500-mile radius of the Project Site

B. Polyvinyl Chloride (PVC) Pipe: ASTM D 3034, SDR 35 PVC gravity sewer pipe, size as indicated, standard manufacture laying length.
   1. Pipe Joints: ASTM D 3212, bell and spigot type, with flexible elastomeric gasket seals. Gaskets shall meet the requirements of ASTM F 477.
   2. Fittings shall be as indicated and required.

C. Cast Iron Soil Pipe: ASTM A 74, extra heavy, coal tar coating, size as indicated, standard manufacture laying length.
   1. Pipe Joints and Fittings: ASTM A 74, hub and spigot joint type manufactured for rubber gaskets. Rubber gaskets per ASTM C 564. Joint lubricant of vegetable oil soap. Fitting types as indicated or required.

D. Concrete Pipe: ASTM C 76, Class IV, standard manufacture laying length.
   1. Pipe Joints: Rubber gaskets, ASTM C 443 with vegetable oil soap joint lubricant.
   2. Mortar Joints: Modified tongue and groove pipe with cement mortar.

E. Corrugated Steel Pipe: ASTM A 819 and AASHTO M 274 Aluminized Steel Type 2 pipe, corrugations and thickness as specified on plans.
   1. Pipe Joints: Shall be watertight joints, made with bands gaskets as specified on plans.

F. High Density Polyethylene Pipe: ADS Type N-12.
   1. Pipe Joints: All joints must meet a modified ASTM 3212 at 3.5-psi held for 10 minutes as certified by an independent testing laboratory.

G. Structures: Standards specified and as indicated.

H. Structure Castings: MDOT-SHA or Frederick County Standards.
   1. Grates for storm drain inlets with grate tops shall be waffle shaped for wheel chair and bicycle safety. Slots shall not exceed 4" by 1 1/2".

I. PVC Pipe for Infiltration Drywell: Schedule 40 Polyvinyl Chloride (PVC) sewer pipe as indicated and required by Frederick County.
   1. Size: As indicated.
   2. Perforations: Drill 1/4-inch perforations all around for entire length as indicated.

3. Fittings: As indicated and required.

J. Cleanouts:
1. Cleanout Ferrules and Plugs: Josam Series No. 58490 with cast iron body and bronze countersunk flanged plug. Size matching pipe size indicated. Contractor shall provide Owner with two "T" handles for recessed plugs.
2. Cleanouts For Use in Paved Walk Areas: Josam Series No. 58360 adjustable floor cleanout with cast iron body and bronze plug and top. Size matching pipe size indicated. Contractor shall provide Owner with one cleanout wrench.
   a. Expansion Joint: ASTM D 994, bituminous preformed joint filler, 1/2 inch thick.
3. Fittings: Shall be as specified for PVC pipe (for pipe materials indicated).

K. Filter Fabric: "Mirafi 140N" manufactured by Mirafi Incorporated, Charlotte, North Carolina. Contractor's Option: "Typar", type 3341 manufactured by Remay Incorporated, Nashville, Tennessee.
1. Quality: Free of defects of flaws, which affect strength or filtering properties.

L. Sand: ASTM C33 Fine Aggregate.

M. Concrete: Refer to Section 33 10 00 "Utility Standards".

N. Reinforcing Steel and Hardware: Refer to Section 33 10 00 "Utility Standards", and as noted:
1. Size and type of steel and hardware shall be as indicated.
2. Exposed reinforcing steel shall be hot dip galvanized, ASTM A 767, Coating Class I.
3. Hardware shall be hot dip galvanized, ASTM A 153.

O. Miscellaneous Products:
1. Underground identification tape manufactured by Allen Systems, Houston, Texas. Tape shall be three inches wide, "Detectatape" type, "Safety Green" color, and marked "Caution Sewer Line Buried Below".

PART 3 - EXECUTION

3.1 DEWATERING, EXCAVATION, OVER-EXCAVATION AND UNSUITABLE EARTH:

A. Refer to Section 33 10 00 "Utility Standards".

3.2 CONNECTIONS TO EXISTING SYSTEM

A. For structure construction over existing pipe, excavate and expose existing pipe at structure location indicated. Adjust structure location as directed by the Owner's Representative in the event existing pipe joint interferes with structure walls, at no increase to Contract Sum. Manually excavate below existing pipe prior to structure base placement. Place concrete base and construct structure as specified. Neatly cut and remove upper half of existing pipe and construct invert flow channel.

B. For pipe connections to existing structures, excavate and expose existing structure. Cut and remove portion of existing structure wall required for pipe connection. Install pipe, through existing structure wall, flush with interior wall surface. Remove portion of existing invert flow channel required for connection and reconstruct as specified. Fill joint between pipe and existing structure wall with cement mortar.

3.3 PIPE:

A. General: Install in accordance with manufacturer's installation instructions and as noted. Inspect each pipe laying length and pipe joint materials for defects. Remove defective products from

project site. Install pipe to horizontal and vertical alignment indicated. Begin installation at lowest system elevation and proceed up-grade. Field cut pipe only where required to complete structure-to-structure closures, install fittings or as specified. Cut pipe to smooth square end.

B. Cast Iron Pipe: Install with spigot end of pipe pointing in direction of flow. Install fittings where indicated or required. Clean and lubricate joints, immediately prior to joining pipe, in accordance with manufacturer's recommendation. Position each laying length in previously installed pipe and push joint tightly together.

C. Concrete Pipe: Install with tongue end of pipe pointing in direction of flow. Clean and thoroughly wet joints immediately prior to joining pipe. Apply thick liberal coat of mastic to groove and tongue. Position each laying length in previously installed pipe and pull joint tightly together with mechanical device designed for pipe jointing.
   1. Clean interior of each joint removing excess cement mortar and finish flush with surface. Fill exterior upper half of pipe joint with cement mortar.

D. Polyvinyl Chloride (PVC) Pipe: Install pipe in accordance with ASTM D 2321, manufacturer's installation instructions, and as noted.
   1. Install with pipe spigot end pointing in flow direction. Begin installation of pipe, with vertical gradient exceeding 10 percent, at lowest elevation and proceed up-grade. Clean bell and spigot interior and exterior surfaces, removing oil, grit and foreign matter. Lubricate pipe ends and gasket in accordance with manufacturer's instructions. Position each laying length of previously installed pipe and manually push joint tightly together.
   2. Field Pipe Cutting: Shape spigot end of cut pipe to resemble manufactured spigot end, with a pipe-beveling tool designed for PVC pipe. Copy the full insertion mark provided on the manufactured spigot end onto the prepared field cut end.

E. Corrugated Steel Pipe: Install in accordance with manufacturer’s recommendations and instructions, and ASTM A 798.

F. High Density Polyethylene Pipe: Install in accordance with manufacturer’s recommendations.

3.4 CLEANOUTS

A. Refer to Section 33 10 00 "Utility Standards" and as noted.

B. Install cleanouts and construct concrete pads of Class "A" concrete as indicated.

C. Cleanout in paved walk area shall be installed without a concrete pad. Top shall be cast into and set flush with finished walk surface.

3.5 STRUCTURES

A. Refer to Section 33 10 00 "Utility Standards" and as noted. Neatly cut pipes flush with interior structure walls. Construct invert flow channels smooth and semicircular in shape. Shape channels with horizontal circular curves, with radii as large as structure will permit or as indicated. Neatly form channels in structure base with bricks and cement mortar. Provide steps in structures exceeding 3.0 feet in depth. Steps shall be per Frederick County Standards. Vertical step spacing per standards specified.

3.6 BACKFILL

A. Refer to Section 33 10 00 "Utility Standards", and as noted.

B. Polyvinyl Chloride (PVC) Pipe: Conduct backfill operations when pipe temperature is below 60 degrees Fahrenheit or during early morning hours to prevent excessive contraction.

C. Underground Identification Tape: Install during backfill operations. Center tape horizontally over pipe, 12 inches above top of pipe.

3.7 STORMWATER MANAGEMENT

A. The Contractor shall be responsible for all efforts necessary to deliver a County approved stormwater management system within 60 days of final site stabilization.

B. The Contractor shall keep all as-built information current on a record set of drawings as the stormwater management system is being constructed.

C. The Contractor shall be responsible for pumping down and cleaning of the system as required for final inspection and acceptance by Frederick County.

D. Final County approval and close out of the stormwater management and sediment control permits are required before contract completion is achieved for stormwater management work.

E. Collect and provide any and all supporting certifications required to satisfy all as-built requirements. Provide certifications from suppliers (including delivery tickets) for materials used in the construction of the facilities (principal spillway, control structure, pvc pipe, aggregate, wetland plantings, granite blocks, rip-rap, geotextile fabric, etc.).

F. Provide the following to the design engineer to support the stormwater as-builts:
   1. Topographic survey of the stormwater management and storm drainage systems in AutoCAD format (.dwg)
   2. Topographic survey of the stormwater management and storm drainage systems plotted in red on mylar. The plot should be on the approved stormwater management plans and profiles. The survey shall include as-built contours, core trench elevations, elevations, dimension, depth of rip-rap, etc. Any deviations from the approved plans shall be shown with a box around the elevation or dimension.
   3. The plan shall be signed and sealed by the contractor's surveyor with the following certification: "I hereby certify to the best of my knowledge and belief that this as-built truly represents existing field conditions including but not limited to sizes, diameters, line and grade, and elevations."
   4. Provide three ties to locate all structures horizontally on the plans.

G. Provide the date/time-stamped digital (.jpg) photographs documenting the chronology of the construction of all stormwater management facilities from beginning to end to the owner in hard copy and electronic format.

- END OF SECTION 33 41 00 -

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