SECTION 000101
PROJECT MANUAL COVER - VOL 2

NEWBURGH ENLARGED CENTRAL SCHOOL DISTRICT
PHASE 3: 2019 CAPITAL IMPROVEMENT PROJECT
405 UNION AVENUE
NEW WINDSOR, NY

VOLUME II

DIVISIONS - 33

CPL PROJECT NO.:13940.18

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NEW YORK STATE EDUCATION DEPARTMENT CONTROL NUMBERS:

HERITAGE MIDDLE SCHOOL	**44-16-00-01-0-039-011**
	DESIGN PROFESSIONAL'S CERTIFICATION ***THE UNDERSIGNED CERTIFIES THAT, TO THE BEST OF HIS OR HER KNOWLEDGE, INFORMATION AND BELIEF, THAT THE "DESIGN CONFORMS TO ALL APPLICABLE PROVISIONS OF THE NEW YORK STATE UNIFORM FIRE PREVENTION CODE AND BUILDING CODE, NEW YORK STATE ENERGY CONSERVATION CODE AND THE BUILDING STANDARDS OF THE NEW YORK STATE EDUCATION DEPARTMENT. AND THAT THE "WORK WILL INVOLVE KNOWN OR SUSPECTED ACBM AND WILL BE DONE IN ACCORDANCE WITH INDUSTRIAL CODE RULE #56"***

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END OF SECTION 000101

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

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

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

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

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

2.3 SLEEVE-SEAL FITTINGS

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

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

2.4 GROUT

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

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

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.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Sleeve-seal fittings.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Sleeve-seal fittings.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 220517

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SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Pipe stands.
6. Equipment supports.

B. Related Sections:
1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
3. Section 220548 "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.

1.5 ACTION SUBMITTALS

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

B. 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.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

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

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 THERMAL-HANGER SHIELD INSERTS

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. 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. Piping Technology & Products, Inc.
   8. Rilco Manufacturing Co., Inc.
   9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength.

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

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

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

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

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

D. High-Type, Single-Pipe Stand:
   1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   2. Base: Plastic.
   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.

2.6 EQUIPMENT SUPPORTS

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

2.7 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

D. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. 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.

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

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

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

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

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger

and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

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

3.4 ADJUSTING

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

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

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 09

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

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

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

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

H. 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.
   2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
   3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
   4. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
   3. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

K. 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. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   5. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
   6. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

L. 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.

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

N. Use powder-actuated fasteners instead of building attachments where required in concrete construction.

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

END OF SECTION 220529

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SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

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

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

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

D. Valve numbering scheme.

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

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. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. 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 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, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

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

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

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

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, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

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

D. 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 high.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass beaded chain.

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

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

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 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 Section 09.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels , complying with ASME A13.1, 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 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:
   1. Low-Pressure, Compressed-Air Piping:
      a. Background Color: Yellow.
      b. Letter Color: Black.
   2. Medium-Pressure, Compressed-Air Piping:
      a. Background Color: Yellow.
      b. Letter Color: Black.
   3. Domestic Water Piping:
      a. Background Color: Yellow.
      b. Letter Color: Black.
   4. Sanitary Waste and Storm Drainage Piping:
      a. Background Color: Yellow.
      b. Letter Color: Black.

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. 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: 1-1/2 inches, round.
      b. Hot Water: 1-1/2 inches, round.
      c. Low-Pressure Compressed Air: 1-1/2 inches, round.
      d. High-Pressure Compressed Air: 1-1/2 inches, round.
   2. Valve-Tag Color:
      a. Cold Water: Natural.
      b. Hot Water: Natural.
      c. Low-Pressure Compressed Air: Natural.
      d. High-Pressure Compressed Air: Natural.

3. Letter Color:
   a. Cold Water: Black.
   b. Hot Water: Black.
   c. Low-Pressure Compressed Air: Black.
   d. High-Pressure Compressed Air: Black.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION 220553

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SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
   2. Encasement for piping.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
   2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

1.6 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Architect, Construction Manager and Owner no fewer than two days in advance of proposed interruption of water service.
   2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type L water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:
1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

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

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

2.4 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Cascade Waterworks Manufacturing.
   b. Dresser, Inc.; Piping Specialties Products.
   c. Ford Meter Box Company, Inc. (The).
   d. JCM Industries.
   e. Romac Industries, Inc.
   f. Smith-Blair, Inc.; a Sensus company.
   g. Viking Johnson.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

H. Install domestic water piping level without pitch and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

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

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

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

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Division 22 "Meters and Gages for Plumbing Piping."

S. Install thermostats in hot-water circulation piping near water heater.

T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

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

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

D. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
   3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
      c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
      d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for two hours. Leaks and loss in test pressure constitute defects that must be repaired.
      e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
      f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Reports: Prepare inspection and test reports and have them signed by authorities having jurisdiction. Submit all reports to Architect.

3.9 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. 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.

3.10 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:
1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours. OR
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Repeat procedures if biological examination shows contamination.
e. Submit water samples in sterile bottles to NYS Department of Health approved lab with results sent to the architect/engineer of record..

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from NYS Department of Health approved lab.

C. Where new fixtures have been added to NYS K-12 school buildings, test samples shall be taken at all new fixtures in accordance with SED testing protocol for Lead. Submit test results to Arch/Engineering/District.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab (and above ground stub up to backflow prevention device), combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12, shall be the following:
1. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.

2. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.

E. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:
1. Soft copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.

F. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:
1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.

G. Aboveground domestic water piping, NPS 2-1/2 to NPS 6, shall be the following:
1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.

H. Aboveground combined domestic water-service and fire-service-main piping (up to backflow prevention device), NPS 6 to NPS 12, shall be one of the following:
1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
2. Fire Protection service shall not transition to Steel pipe until downstream of the backflow prevention device.

3.12 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Backflow preventers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.
   1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61.

B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   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. Cash Acme; a division of Reliance Worldwide Corporation.
      b. Conbraco Industries, Inc.
      c. FEBCO; a division of Watts Water Technologies, Inc.
      d. Honeywell International Inc.
      e. Legend Valve.
      f. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.

g. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.

2. Standard: ASSE 1012.
3. Operation: Continuous-pressure applications.
4. Body: Bronze.
5. End Connections: Union, solder joint.
6. Finish: Rough bronze.

B. Reduced-Pressure-Principle Backflow Preventers - **RPZ**:

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. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company. Equal to 909 series for main service entrance, 909 or 009 for other internal devices.
   b. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
   c. Conbraco Industries, Inc.
   d. FEBCO; a division of Watts Water Technologies, Inc.
   e. Flomatic Corporation.
   f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1013. And listed as approved by FCCCHR.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Size: As noted on plan
6. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
8. Configuration: Designed for horizontal, straight-through flow.
9. Accessories:
   a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
   b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
   c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
10. Provide downspout with Hinged Cover equal to JR Smith 1775 for all through wall drain terminations.

C. Double-Check, Backflow-Prevention Assemblies – DC:

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. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company. Equal to 007 series.
   b. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
   c. Conbraco Industries, Inc.
   d. FEBCO; a division of Watts Water Technologies, Inc.
   e. Flomatic Corporation.
   f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.

5. Size: as noted on plans
6. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
8. Configuration: Designed for horizontal, straight-through flow.
9. Accessories:
   a. ValvesNPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
   b. ValvesNPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

D. Beverage-Dispensing-Equipment Backflow Preventers:
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. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company., equal to SD-3
   b. Conbraco Industries, Inc.
   c. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded.
7. Ensure drainage is available for atmospheric vent

E. Reduced-Pressure-Detector, Fire-Protection Backflow Preventer 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. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. FEBCO; SPX Valves & Controls.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Wilkins Water Control Products Division.
2. Standards: ASSE 1047 and UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle one-third of flow range.
5. Body Material: Cast iron with interior lining complying with AWWA C550 or that is FDA approved.
6. End Connections: Flanged.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: UL 262, "Approval Guide," published by FM Global, listing; OS&Y gate type with flanged ends on inlet and outlet.
   b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.
   c. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

F. Double-Check, Detector-Assembly Backflow Preventers –DCDA:

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. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company. Equal to 709 series.
   b. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
   c. Conbraco Industries, Inc.
   d. FEBCO; a division of Watts Water Technologies, Inc.
   e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1048 and is FM Global approved or UL listed.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Size: as noted
6. Body: Cast iron with interior lining that complies with AWWA C550 or that is FDA approved.
7. End Connections: Flanged.
8. Configuration: Designed for horizontal, straight-through flow.
9. Accessories:
   a. Valves: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
   b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

G. Hose-Connection Backflow Preventers:
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. Conbraco Industries, Inc.
   b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
   c. Woodford Manufacturing Company; a division of WCM Industries, Inc.
2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 1/2 or NPS 3/4.
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install water-control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

C. Install balancing valves in locations where they can easily be adjusted.

D. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve.

F. Install water-hammer arresters in water piping according to PDI-WH 201.

G. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

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. Intermediate atmospheric-vent backflow preventers.
   3. Reduced-pressure-principle backflow preventers.
   4. Double-check, backflow-prevention assemblies.
   5. Dual-check-valve backflow preventers.
   6. Double-check, detector-assembly backflow preventers.
   7. Water pressure-reducing valves.
   8. Calibrated balancing valves.
   9. Primary, thermostatic, water mixing valves.
   10. Supply-type, trap-seal primer valves.
   11. Trap-seal primer systems.

3.4 FIELD QUALITY CONTROL

A. Test each backflow prevention device including, reduced pressure principle backflow, double check backflow and/or double-check detector assembly backflow as required by NYS Cross Connection Control Guidelines, and as required by the manufacturer.
   1. Complete test reports as required by NYS DOH, including the DOH-1013 form (part A).

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable 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 221119

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SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground metal piping.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.
   2. Waste, Force-Main Piping: 100 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency, as well as collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect, Construction Manager, and Owner no fewer than two days in advance of proposed interruption of sanitary waste service.

2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

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 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, 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. CISPI, Hubless-Piping Couplings:
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. ANACO-Husky.
   b. Fernco Inc.
   c. Mission Rubber Company; a division of MCP Industries, Inc.
   d. Tyler Pipe.
2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Heavy-Duty, Hubless-Piping Couplings:
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. ANACO-Husky.
   b. Clamp-All Corp.
   c. Mission Rubber Company; a division of MCP Industries, Inc.
   d. Tyler Pipe.
2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B 88, Type Lwater tube, drawn temper.

D. Copper Pressure Fittings:
1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. 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.

E. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

F. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Shielded, Nonpressure Transition Couplings:
a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1) Mission Rubber Company; a division of MCP Industries, Inc.
b. Standard: ASTM C 1460.
c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
4. Pressure Transition Couplings:
a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1) Dresser, Inc.
2) EBAA Iron, Inc.
3) JCM Industries, Inc.
4) Romac Industries, Inc.
5) Smith-Blair, Inc.; a Sensus company.
6) The Ford Meter Box Company, Inc.
7) Viking Johnson.
b. Standard: AWWA C219.
c. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
d. Center-Sleeve Material: Stainless steel.
e. Gasket Material: Natural or synthetic rubber.
f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:
   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) Capitol Manufacturing Company.
      2) Hart Industries International, Inc.
      3) Jomar International Ltd.
      4) Matco-Norca, Inc.
      5) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      6) Wilkins; a Zurn company.
   b. Description:
      1) Standard: ASSE 1079.
      2) Pressure Rating: 125 psig minimum at 180 deg F.
      3) End Connections: Solder-joint copper alloy and threaded ferrous.
3. Dielectric Flanges:
   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) Capitol Manufacturing Company.
      2) Matco-Norca, Inc.
      3) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      4) Wilkins; a Zurn company.
   b. Description:
      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 125 psig minimum at 180 deg F.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
4. Dielectric-Flange Insulating Kits:
   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) Advance Products & Systems, Inc.
      2) Calpico, Inc.
      3) Pipeline Seal and Insulator, Inc.
   b. Description:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Pressure Rating: 150 psig.
      3) Gasket: Neoprene or phenolic.
      4) Bolt Sleeves: Phenolic or polyethylene.
      5) Washers: Phenolic with steel backing washers.
5. Dielectric Nipples:
   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) Elster Perfection.
      2) Grinnell Mechanical Products.
      3) Matco-Norca, Inc.

4) Precision Plumbing Products, Inc.
5) Victaulic Company.

b. Description:
1) Standard: IAPMO PS 66
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig at 225 deg F.
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Vent termination through roof shall be min. 18” above roof.

L. 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. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. 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.

M. 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.

N. 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 and smaller; 1 percent downward in direction of flow for piping NPS 4 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.

O. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

P. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

Q. Install engineered soil and waste drainage and vent piping systems as follows:
   1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.

R. Install copper, force-main tubing according to CDA's "Copper Tube Handbook."

S. Install force mains at elevations indicated.

T. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
   2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

U. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.

C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Shielded, nonpressure transition couplings.
   3. In Aboveground Force Main Piping: Fitting-type transition couplings.
   4. In Underground Force Main Piping:
      a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
      b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
   3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.
   4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 220523 "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves:
   1. Install shutoff valve on each sewage pump discharge.
   2. Install gate or full-port ball valve for piping NPS 2 and smaller.
   3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   3. Vertical Piping: MSS Type 8 or Type 42, clamps.
   4. Install individual, straight, horizontal piping runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   6. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.

2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

J. 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. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
6. Equipment: Connect 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 and larger.

D. Connect force-main piping to the following:
1. Sewage Pump: To sewage pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. 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. 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. 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.

D. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   4. Prepare reports for tests and required corrective action.

E. Reports: Prepare inspection and test reports and have them signed by authorities having jurisdiction. Submit all reports to Architect.

3.10 CLEANING AND PROTECTION

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.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller shall be the following:
1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Copper DWV tube, copper drainage fittings, and soldered joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, soil and waste piping NPS 5 and larger shall be the following:
1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 4 and smaller shall be the following:
1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Copper DWV tube, copper drainage fittings, and soldered joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Underground, soil, waste, and vent piping NPS 4 and smaller shall be the following:
1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

F. Underground, soil and waste piping NPS 5 and larger shall be the following:
1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

G. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be the following:
1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
2. Galvanized-steel pipe, pressure fittings, and threaded joints.

END OF SECTION 221316

SECTION 221329 - SEWAGE 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 sewage pumps.
2. Sewage-pump basins and basin covers.
3. Packaged, submersible sewage-pump units.

1.3 ACTION SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 PACKAGED, SUBMERSIBLE SEWAGE-PUMP UNITS

A. Packaged, Submersible, Duplex Grinder, Sewage-Pump Units:
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. Weil Pumps
b. Pentair Pumps
c. Barnes Pumps
d. Hydromatic Pumps

e. Flyght Pumps

2. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, duplex grinder, sewage-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron.
5. Impeller: Stainless-steel grinder.
6. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
7. Control: Manufacturer's standard panel for two pumps.
8. Controls: Alternating duplex pumps including four float switches.
9. Pump Discharge Piping: Factory or field fabricated, Stainless steel with stainless steel check valve and ball valve.
10. Basin: Watertight fiberglass, 5’ diameter by 10’ deep, with inlet and outlet pipe connection at dimensions shown on plan. Gastight cover with pump vent connections.

B. Capacities and Characteristics:
1. System Capacity: 50 gpm, 108’TDH.
2. Number of Pumps: Two.
3. Each Pump:
a. Capacity: 40 gpm.
b. Total Dynamic Head: 60 feet.
c. Discharge Pipe Size: 1 1/4” NPS.
d. Motor Horsepower: 1/3hp.
e. Electrical Characteristics:
1) Volts: 208-230.
2) Phases: Three.
3) Hertz: 60.
4. Alternator Control Required: Yes.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.2 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.3 CONNECTIONS

A. Comply with requirements for piping specified for Sanitary Force Main. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

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

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 221329

SECTION 221413 - 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. Section Includes:
1. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Encasement for underground metal piping.

1.3 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.

B. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. Storm piping directly over Operating rooms shall be supported per Seismic requirements. Importance Factor 1.5.
2. All other storm piping: Importance Factor 1.0 (no seismic support required).

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
1. Notify Architect, Construction Manager, and Owner no fewer than two days in advance of proposed interruption of storm-drainage service.

2. Do not proceed with interruption of storm-drainage service without Owner's written permission.

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 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service classes.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
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. ANACO-Husky.
   b. Fernco Inc.
   c. Mission Rubber Company; a division of MCP Industries, Inc.
   d. Tyler Pipe.
2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:
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. ANACO-Husky.
   b. Clamp-All Corp.
   c. Mission Rubber Company; a division of MCP Industries, Inc.
   d. Tyler Pipe.
2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Solvent Cement: ASTM D 2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Shielded, Nonpressure Transition Couplings:
   a. Manufacturers: Subject to compliance with requirements, [**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**]:
      1) Mission Rubber Company; a division of MCP Industries, Inc.
   b. Standard: ASTM C 1460.
   c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Dielectric Fittings:
1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:
   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) Capitol Manufacturing Company.
      2) Hart Industries International, Inc.
      3) Jomar International Ltd.
      4) Matco-Norca, Inc.
      5) McDonald, A. Y. Mfg. Co.
      6) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      7) Wilkins; a Zurn company.
   b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 150 psig at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:
   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) Capitol Manufacturing Company.
      2) Matco-Norca, Inc.
      3) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      4) Wilkins; a Zurn company.
   b. Description:
      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 150 psig.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
4. Dielectric-Flange Insulating Kits:
   a. M 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) Advance Products & Systems, Inc.
      2) Calpico, Inc.
      3) Pipeline Seal and Insulator, Inc.
   b. Description:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Pressure Rating: 150 psig.
      3) Gasket: Neoprene or phenolic.
      4) Bolt Sleeves: Phenolic or polyethylene.
      5) Washers: Phenolic with steel-backing washers.
5. Dielectric Nipples:
   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) Elster Perfection.
      2) Grinnell Mechanical Products.
      3) Matco-Norca, Inc.
      4) Precision Plumbing Products, Inc.
      5) Victaulic Company.
   b. Description:
      1) Electroplated steel nipple complying with ASTM F 1545.
      2) Pressure Rating: 300 psig at 225 deg F.
      3) End Connections: Male threaded or grooved.
      4) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. 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 from layout are approved on coordination drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. 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.

L. 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.

M. 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 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

N. 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.

O. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
   2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Shielded, nonpressure transition couplings.
   3. In Aboveground Force-Main Piping: Fitting-type transition couplings.
   4. In Underground Force-Main Piping:
      a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
      b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.
   3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.
   4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 220523 "General-Duty Valves for Plumbing Piping."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   3. Vertical Piping: MSS Type 8 or Type 42, clamps.
   4. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting[**, valve,**] and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. 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.
1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Comply with requirements for cleanouts and drains specified in Section 221423 "Storm Drainage Piping Specialties."

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.

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. 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 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. From 15 minutes before inspection starts until 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.

D. Reports: Prepare inspection and test reports and have them signed by authorities having jurisdiction. Submit all reports to Architect.

3.10 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.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 8 and smaller shall be the following:
1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Underground storm drainage piping NPS 8 and smaller shall be the following:
1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221413

SECTION 221423 - 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. Through-penetration firestop assemblies.
5. Flashing materials.

1.3 ACTION 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, Primary General-Purpose Roof Drains RD-1:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Josam Company. Equal to 21500-AE
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe.
   e. Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 12-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Outlet: Bottom.
7. Extension Collars: Required.
8. Underdeck Clamp: Required.
9. Sump Receiver Plate: Required.
10. Dome Material: Aluminum.

B. Cast-Iron, Large-Sump, Dual Outlet Secondary General-Purpose Roof Drains RD-2:

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. Zurn Equal to Z103-45
   b. Josam Company
   c. MIFAB, Inc.
   d. Smith, Jay R. Mfg. Co.
   e. Tyler Pipe.
   f. Watts Water Technologies, Inc.
2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Dimension of Body: 12-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Outlet: Bottom.
7. Extension Collars: Required.
8. Underdeck Clamp: Required.
9. Sump Receiver Plate: Required.
10. Dome Material: Aluminum.
11. Water Dam: 2 inches high.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Boots:
1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 outlet.

B. Conductor Nozzles:
1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.3 CLEANOUTS

A. Floor Cleanouts FCO:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Josam Company.
   b. Smith, Jay R. Mfg. Co.
   c. Tyler Pipe.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for adjustable housing cast-iron soil pipe with cast-iron ferrule cleanouts.
3. Size: Same as connected branch.
4. Body or Ferrule Material: Cast iron.
5. Clamping Device: Not required.
6. Outlet Connection: Spigot.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.

10. Frame and Cover Shape: Round.
11. Top-Loading Classification: Medium Duty.
12. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe.
   e. Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
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: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk, brass.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts WCO:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe.
   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, cast-iron 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: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.4 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.

2.5 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M,12 oz./sq. ft..

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 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.
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.

B. Install downspout boots at grade with top 12 inches above grade. Secure to building wall.

C. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

D. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 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 for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

E. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

F. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

G. Install test tees in vertical conductors and near floor.

H. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

I. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

J. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
   2. 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 the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

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.

END OF SECTION 221423

SECTION 224716 - PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pressure water coolers and related components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Pressure Water Coolers **DF-1**: Wall mounted, accessible, with bottle filler.
   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. Elkay Manufacturing Co. Equal to VRC8WSK
      b. Halsey Taylor.
      c. Haws Corporation.
      d. Tri Palm International, LLC; Oasis Brand.
   2. Cabinet: Bi-level with two attached cabinets, vinyl-covered steel with stainless-steel top, one bottle filler station above one cabinet.
   3. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
   4. Control: Push bar.
   5. Drain: Grid with NPS 1-1/4 tailpiece.
   6. Supply: NPS 3/8 with shutoff valve.
   7. Filter: Filter NSF 42 & 53 for lead and particulate w/ visual filter monitor.
   8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
   9. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
      a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   10. Capacities and Characteristics:
      a. Cooled Water: 8 gph.

b. Cooled-Water Temperature: 50 deg F.
c. Electrical Characteristics:
1) Volts: 120-V ac.
2) Phase: Single.
3) Hertz: 60.

11. Support: ASME A112.6.1M, Type I water-cooler carrier.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation.

D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings.

F. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball, gate, or globe shutoff valve on water supply to each fixture.

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224716

SECTION 230001 - GENERAL PROVISIONS FOR MECHANICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of this Section apply to work in every Section of Division 23 equally as if incorporated therein.

1.2 WORK INCLUDED

A. Work included in Division 23 - Mechanical: Materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for Mechanical Work covered by all sections within this Division.

1.3 SCOPE

A. Division of the Specification into sections is for the purpose of simplification alone. Responsibility for the work of various trades shall rest with the Contractor. Various sections of this Division are related to each other as well as the mechanical drawings. Examine all drawings and read all applicable parts of the project manual in order to insure complete execution of all work in this Division, coordinating where required with other trades in order to avoid conflicts.

B. These specifications and accompanying drawings are intended to cover the furnishing of all labor, materials, equipment and services necessary for the complete installation and acceptable performance of the mechanical systems. Small items of material, equipment and appurtenances not mentioned in detail or shown on the drawings, but necessary for complete and operating systems shall be provided by this contractor without additional charge to the Owner and shall be included under this contract.

C. In general, specifications establish the quality of material, equipment and workmanship. The contract documents are intended to secure for the Owner, a first-class installation in every respect. Labor shall be performed by skilled mechanics, and the entire facility, when delivered to the Owner, shall be ready for satisfactory and efficient operation.

D. The Contractor shall carefully examine the drawings and specifications before accepting the contract. He shall call attention to any changes or additions which, in his opinion, are necessary to make possible the fulfillment of any guarantee called for by these specifications; failing which, it shall be deemed that he has accepted full responsibility for all such guarantees.

E. The contractor shall put his work in place as fast as is reasonably possible. He shall, at all times, keep a competent foreman in charge of the work, to make decisions necessary for the diligent advancement of the work. The Contractor shall facilitate the inspection of the work by the Owner's Representative.

F. The Contractor shall coordinate all work in the building in order to facilitate intelligent execution of the work. He shall also remove any rubbish as expeditiously as possible.

G. Materials or products specified herein and/or indicated on the drawings by trade’s names, manufacturer's names, model number or catalog numbers establish the quality of materials or products to be furnished. Model numbers are to be confirmed by the manufacturer to provide required capacities and material to meet the specifications and design intent. In no instance shall

an obsolete, incomplete or inaccurate trade name, manufacturer name, model number or catalog number indicated on the drawings, result in additional charges to the owner.

H. Points of connection or continuation of work under this contract are so marked on drawings or herein specified. In case of any doubt as to the required exact location of such points, the Owner's Representative shall decide and direct.

I. The plumbing contractor shall provide water services to within two (2) feet of HVAC equipment requiring same, and shall terminate service with a shutoff valve. The mechanical contractor shall make the final connection to the equipment.

1.4 REFERENCE STANDARDS, CODES AND REGULATIONS

A. Requirements of Regulatory Agencies:

1. Nothing contained in these specifications or shown on the drawings shall be construed to conflict with any State or local laws, ordinances, rules and regulations, the UL and NFPA regulations. The Contractor shall make all changes required by the enforcing authorities. Where alterations to and / or deviations from the Contract Documents are required by the authorities having jurisdiction, report the requirements to the Engineer and secure acceptance before work is started. All such changes shall be made in a manner acceptable to the Engineer and shall be made without cost to the Owner.
2. When drawings or specifications exceed requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement. All work shall be done in full conformity with the requirements of all authorities having jurisdiction. Installation shall be made in compliance with all applicable regulations, and utility company rules, all of which shall be considered a part of this specification and shall take precedence in the order of listing.
3. It is not the intent of drawings or specifications to repeat requirements of codes except where necessary for completeness in individual sections.

B. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in this Division, in addition to other standards which may be specified in individual sections:

1. AABC Associated Air Balance Council
2. ADC Air Diffuser Balance Council
3. AMCA Air Moving and Conditioning Association
4. AGA American Gas Association
5. ANSI American National Standards Institute
6. ARI Air Conditioning and Refrigeration Institute
7. ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
8. ASME American Society of Mechanical Engineers
9. ASTM American Society for Testing and Materials
10. CISPI Cast Iron Soil Pipe Institute
11. ETL ETL Testing Laboratories
12. FMS Factory Mutual Engineering and Research Corporation
13. NAPHCC National Standard Plumbing Code
14. NEMA National Electrical Manufacturer's Association
15. NFPA National Fire Protection Association
16. NBFU National Board of Fire Underwriters
17. NEC National Electric Code
18. OSHA Occupational Safety and Health Administration
19. PDI Plumbing Drainage Institute

20. SMACNA Sheet Metal & Air Conditioning Contractors National Association
21. UL Underwriters Laboratories, Inc.

C. Furnish and file with the proper authorities, all drawings required by them in connection with the work. Contractor shall secure and obtain all approvals, permits, licenses and inspections and pay all legal and proper fees and charges in this connection, before commencing work in order to avoid delays during construction. He shall deliver the official records of the granting of the permits, etc., to the Owner's Representative.

1.5 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

B. Supply all equipment and accessories new and free from defects.

C. Supply all equipment and accessories in compliance with the applicable standards listed in Article 1.4 of this section with all applicable national, state and local codes.

D. All items of a given type shall be the product of same manufacturer.

1.6 DESCRIPTION OF BID DOCUMENTS

A. Specifications:
1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.
3. Words or phrases such as "The Contractor shall", "shall be", "furnish", "provide", "a", "an", "the", and "all" may have been omitted for brevity.

B. Drawings: Mechanical drawings under this contract are made a part of these specifications. Deviations from these specifications as noted below must have the approval of the Engineer or Construction Manager without an increase in contract price.
1. The drawings shall be considered as being diagrammatic and for bidding purposes only. Intention is to show size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement. The attention of the contractor is called to the fact that while these drawings are generally to scale and are made as accurately as the scale will permit, all critical dimensions shall be determined in the field. They are not to be considered as erection drawings.
2. The drawings do not indicate every fitting, elbow, offset, valve, etc. which is required to complete the job. Contractor shall prepare field erection drawings as required for the use of his mechanics to insure proper installation.
3. Scaled and figured dimensions are approximate and are for estimating purposes only. Indicated dimensions are limiting dimensions.
4. Before proceeding with work check and verify all dimensions in field.
5. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
6. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
7. For exact locations of building elements, refer to dimensional Architectural/Structural drawings.

C. Description of systems: Provide all materials to provide functioning systems in compliance with performance requirements specified, and any modifications resulting from reviewed shop drawings and field coordinated drawings.
   1. Installation of all systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination drawings.

D. Do not use equipment exceeding dimensions indicated or equipment or arrangements that reduce required clearances or exceed specified maximum dimensions.

E. If any part of Specifications or Drawings appears unclear or contradictory, apply to Architect for his interpretation and decision as early as possible, including during bidding period.
   1. Do not proceed with work without Engineer's decision.

1.7 EQUIPMENT MANUFACTURERS

A. The first named manufacturer is used as the basis of design. Other named manufacturers are identified as equivalent manufacturers, not equivalent products. Naming other manufacturers does not necessarily imply conformance of any specific product with the written specifications.

B. The contractor is required to verify that equipment and material to be used on the project meets the requirements of the specifications and will physically fit the available space, clearance and service requirements of the particular piece of equipment and include all pertinent information when he submits material for acceptance. Contractor shall also be responsible for and bear the cost of any modifications to openings available or anticipated as being available for rigging equipment to its final installation place. This shall include openings in exterior envelope, walls and roofs, interior walls, corridors, passage ways or door openings. Any on site dismantling and any reassembly of equipment made necessary by impediment to the rigging of said equipment shall be the sole responsibility of the contractor.

C. Contract document indicates power and physical requirements based on the equipment manufacturer's data as first named. If equipment requiring more system capacity is furnished, the contractor shall be responsible for the cost associated with modifying the design and installation of associated services, including any redesign costs associated with the engineer’s review.

1.8 DEFINITIONS

A. "Provide": To supply, furnish, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.

B. "Install": To erect, mount and connect complete with related accessories.

C. "Supply", "Furnish": To purchase, procure, acquire and deliver complete with related accessories.

D. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

E. "Piping": Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

F. "Wiring": Raceway, fittings, wire, boxes and related items.

G. "Concealed": Items referred to as hidden from normal sight, embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.

H. "Exposed": Not installed underground or "concealed" as defined above.

I. "Indicated", "Shown", or "Noted": As indicated, shown or noted on drawings or specifications.

J. "Directed": Directed by Engineer.

K. "Similar" or "Equal": Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified product.

L. "Reviewed", "Satisfactory", or "Directed": As reviewed, satisfactory, or directed by or to Engineer.

M. "Motor Controllers": Manual or magnetic starters (with or without switches), individual pushbuttons or hand-off-automatic (HOA) switches controlling the operation of motors.

N. "Control or Actuating Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

O. "Remove": Dismantle, demolish and take away from the site and dispose of in accordance with all applicable rules and regulations or, should the Owner so require, deliver to a location as designated by the Owner for the use of the Owner, at no additional cons to the Owner.

P. "Replace": Remove existing and provide an equivalent product or material as specified.

Q. "Extract (and Reinstall) ": Carefully disassemble, dismantle existing, save or store where directed by the Owner, in such a manner as to preserve the existing condition and reinstall as indicated on the drawings or as described in the specifications.

R. Where any device or piece of equipment is referred to in the singular number, such reference shall be deemed to apply to as many devices as are required to complete the installation.

1.9 JOB CONDITIONS

A. This contractor shall investigate all conditions affecting his work and shall provide such offsets, fittings, valves, sheet metal work, etc., as may be required to meet conditions at the building.

B. The contractor shall verify all measurements at the building site and shall be responsible for the correctness of same before ordering materials or before starting work of any Section.
   1. Report to Architect, in writing, conditions which will prevent proper provision of this work.
   2. Beginning work of any Section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by Contractor.
   3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

C. Piping and ductwork shall be concealed or run behind furring in finished spaces unless otherwise noted to be run exposed.

D. Horizontal piping and ductwork not run below slabs on grade shall be run as close as possible to underside of roof or floor slab above and parallel to building lines. Maintain maximum headroom in all areas.

E. Determine possible interference between trades before the work is fabricated or installed. The contractor must coordinate his work to insure that erection will proceed without such interference. Coordination is of paramount importance and no request for additional payment will be considered where such request is based upon interference between trades.

F. Connections to Existing Work:
   1. Install new work and connect to existing work with minimum of interference to existing facilities.

2. Temporary shutdowns of existing services:
   a. At no additional charges
   b. At times not to interfere with normal operation of existing facilities.
   c. Only with written consent of Owner.
3. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
4. Restore existing disturbed work to original condition.

G. Removal, extraction and relocation of existing work.
1. The work includes demolition or removal of all construction indicated or specified. All materials resulting from demolition work, except as indicated or specified otherwise, shall become the property of the Contractor and shall be removed from the site. Rubbish and debris shall be removed from the site daily unless otherwise directed so as to not allow accumulation inside or outside the building. Materials that cannot be removed daily shall be stored in areas specified by the Owner.
2. Title to all materials and equipment to be demolished, excepting Owner salvage and historical items, is vested in the Contractor upon receipt of notice to proceed. The Owner will not be responsible for the condition, loss or damage to such property after notice to proceed.
3. The Owner reserves the "Right of First Refusal" on all material for salvage. Material for salvage shall be stored as approved by the Owner. Salvage materials shall be removed from the site before completion of the Contract. Material for salvage shall not be sold on the site.
4. Property of the Owner: Salvaged items remaining the property of the Owner shall be removed in a manner to prevent damage and packed or crated to protect the items from damage while in storage or during shipment and relocated by the contractor at no cost, to the Owners designated storage facility on the site. Containers shall be properly identified as to contents.
5. Damaged Items: Items damaged during removal or storage shall be repaired or replaced to match existing.
6. Disconnect, remove or relocate material, equipment, plumbing fixtures, piping and other work noted and required by removal or changes in existing conditions.
7. Where existing pipes, conduits and/or ducts which are to remain prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits, and/or ducts.
8. Provide new material and equipment required for relocated equipment.
9. Plug or cap active piping or ductwork behind or below finish.
10. Do not leave long dead-end branches.
    a. Cap or plug as close as possible to active line.
11. Remove unused piping, ductwork and equipment.
12. Dispose of unusable piping, ductwork and material.

1.10 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping or ductwork:
1. Prohibited, except as noted, in:
   a. Electric rooms and closets.
   b. Telephone rooms and closets.
   c. Elevator machine rooms.
   d. Electric switchboard room.
2. Prohibited, except as noted, over or within 5 ft. of:

a. Transformers.
b. Substations.
c. Switchboards.
d. Motor control centers.
e. Standby power plant.
f. Bus ducts.
g. Electrical panels.

3. Drip pans under piping:
   a. Only where unavoidable and approved.
   b. 18 gauge galvanized steel.
      1) With bituminous paint coating.
   c. Reinforced and supported.
   d. Watertight.
   e. With 1-1/4 inch drain outlet piped to floor drain or service sink.

1.11 TEMPORARY FACILITIES

A. Temporary facilities are not included within this Section.

1.12 SPECIAL TOOLS

A. Furnish to Owner at completion of work:
   1. One set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of the Division.
   2. "Special tools": those not normally found in possession of mechanics or maintenance personnel.
   3. One pressure grease gun for each type of grease required.
      a. With adapters to fit all lubricating fittings on equipment.
      b. Include lubricant for lubricated plug valves.

1.13 PRODUCT DELIVERY, HANDING AND STORAGE

A. Provide adequate and secure storage facilities for materials and equipment during the progress of the work.

B. Contractor shall be responsible for the condition of all materials and equipment employed in the mechanical installation until final acceptance by the Owner. Protect same from any cause whatsoever.

C. Where necessary, ship in crated sections of size to permit passing through available space.

D. Ship equipment in original packages, to prevent damaging or entrance of foreign matter.

E. Handle and ship in accordance with manufacturer's recommendations.

F. Provide protective coverings during construction.

G. Replace at no expense to Owner, equipment or material damaged during storage or handling, as directed by Engineer.

H. Tag all items with weatherproof tag, identifying equipment by name and purchase order number.

I. Include packing and shipping lists.

J. Adhere to special requirements as specified in individual sections.

1.14 PROTECTION OF MATERIALS

A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.

B. Provide temporary storage facilities for materials and equipment.

C. Material, equipment or apparatus damaged because of improper storage or protection will be rejected.
   1. Remove from site and provide new, duplicate, material, equipment or apparatus in replacement of that rejected.

D. Cover motors and other moving machinery to protect from dirt and water during construction. Rotate moving equipment, shafts, bearings, motors etc. to prevent corrosion and to circulate lubricants.

E. Protect premises and work of other Divisions from damage arising out of installation of work of this Division.
   1. Contractor shall be responsible for the replacement of all damaged or defective work, materials or equipment. Do not install sensitive or delicate equipment until major construction work is completed.
   2. Remove replaced parts from premises.

F. Make good any damage to the work caused by floods, storms, accidents, acts of God, acts of negligence, strikes, violence or theft up to time of final acceptance by the Owner.

G. Do not leave any mechanical work in a hazardous condition, even temporarily.

1.15 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by representative of the Engineer.

B. Advise Architect and Engineer that work is ready for review at following times:
   1. Prior to backfilling buried work.
   2. Prior to concealment of work in walls and above ceilings.
   3. When all requirements of Contract have been completed.

C. Neither backfill nor conceal work without Engineer's consent.

D. Maintain on job a set of Specifications and Drawings for use by Engineer's representatives.

1.16 SCHEDULE OF WORK

A. Arrange work to conform to schedule of construction established or required to comply with Contract Documents.

B. In scheduling, anticipate means of installing equipment through available openings in structure.

C. Confirm in writing to Architect and Engineer, within 30 days of signing of contract, anticipated number of days required to perform test, balance, and acceptance testing of mechanical systems.
   1. This phase must occur after completion of mechanical systems, including all control calibration and adjustment, and requires substantial completion of the building, including closure, ceilings, lighting, partitioning, etc.
   2. Submit for approval at this time, names and qualifications of test and balancing agencies to be used.

D. Arrange with Owner schedule for work in each area.

E. Unless otherwise directed by Owner, perform work during normal working hours.

F. Work delays:
1. In case noisy work interferes with Owner's operations, Owner may require work to be stopped and performed at some other time, or after normal working hours.

1.17 ACCESS TO MECHANICAL WORK

A. Access doors in walls and ceilings.

B. Access Units Fire-Resistance Ratings: Where fire-resistance rating is indicated for construction penetrated by access units, provide UL listed-and-labeled units, except for units which are smaller than minimum size requiring ratings as recognized by governing authority.

C. Product Data, Access Units: Submit manufacturer's technical data and installation instructions for each type of access door assembly, including setting drawings, templates, instructions and directions for installation of anchorage devices.

D. Furnish to the general contractor all access doors necessary for access through inaccessible wall or ceiling construction, for installation by the general contractor. Information on the size and location of the subject access doors is to be communicated in writing to the general contractors during the bidding period.

1.18 CONCRETE FOR MECHANICAL WORK

A. Concrete for Mechanical Work
1. Basins and curbs for mechanical equipment.
2. Mechanical equipment foundations and housekeeping pads.
3. Inertia bases for isolation of mechanical work.
4. Rough grouting in and around mechanical work.
5. Patching concrete cut to accommodate mechanical work.

B. Quality control testing for concrete is required as work of this section.

C. Concrete Work Codes and Standards:
1. Comply with governing regulations and, where not otherwise indicated, comply with the following industry standards; whichever is the most stringent in its application to work in each instance.
ACI 301 "Specifications for Structural Concrete for Buildings"
ACI 311 "Recommended Practice for Concrete Inspection"
ACI 318 "Building Code Requirements for Reinforced Concrete"
ACI 347 "Recommended Practice for Concrete Form work"
ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete"
Concrete Reinforcing Steel Institute's, "Manual of Standard Practice"

D. Submittals: Shop Drawings, Mechanical Concrete Work: Submit shop drawings for structural type concrete work, showing dimensions of formed shapes of concrete; bending, placement, sizes and spacing of reinforcing steel; location of anchors, isolation units, hangers and similar devices to be integrated with concrete work; and piping penetrations, access openings, inlets and other accessories and work to be accommodated by concrete work.

E. Laboratory Test Reports, Mechanical Concrete Work: Submit laboratory test reports for concrete work materials, and for tested samples of placed concrete (where required as work of this section).

1.19 NOISE REDUCTION

A. Cooperate in reducing objectionable noise or vibration caused by mechanical systems.
   1. To extent of adjustments to specified and installed equipment and appurtenances.

B. Correct noise problems caused by failure to install work in accordance with Contract Documents.
   1. Include labor and materials required as result of such failure.

1.20 CUTTING AND PATCHING

A. Provide all carpentry, cutting and patching required for proper installation of material and equipment specified.

B. Do not cut or drill structural members without consent of Architect.

1.21 COORDINATION DRAWINGS

A. Layout Shop Drawings Required:
   1. Prepare layout shop drawings for all areas; minimum 3/8 inch scale.
   2. Individual coordinated trade layout drawings are to be prepared for all areas.
   3. General Contractor is to assure that each trade has coordinated work with other trades, prior to submittal where submittal is required.
      a. Include stamp on each submittal indicating that layout shop drawing has been coordinated.
   4. No layout shop drawing will be reviewed without stamped and signed coordinated assurance by General Contractor.
   5. All changes shall be clearly marked on each submitted layout drawing.
   6. Drawings shall show work of all trades including but not limited to'
      a. Ductwork.
      b. Piping: All Trades.
      c. Mechanical Equipment.
      d. Electrical Equipment.
      e. Main Electrical conduits and bus ducts.
      f. Equipment supports and suspension devices.
      g. Structural and architectural constraints.
      h. Show location of:
         1) Valves
         2) Piping specialties
         3) Dampers
         4) Access Doors
         5) Control and electrical panels
         6) Disconnect switches
   7. Drawings shall indicate coordination with work in other Divisions that must be incorporated in mechanical spaces, including, but not limited to:
      a. Elevator equipment.
      b. Cable trays not furnished under Division 16.
      c. Computer equipment.
   8. Submission of drawings:
      a. Prepare reproducible drawings.
      b. Submit to other trades for review of space allocated to all trades.
      c. Revise drawings to compensate for requirements of existing conditions and conditions created by other trades.
      d. Review revisions and other trades.

e. Submit one reproducible and one blueline print to Engineer for review.

9. Final prepared drawings shall show that other trades affected have made reviews and signed, by each trade, at completions of coordination.
   a. General Contractor
   b. Include stamp on each submittal indicating that layout shop drawing has been coordinated.
10. No layout shop drawing will be reviewed without stamped and signed coordination assurance by General Contractor.

B. Shop Drawings:
1. Layout drawings of mechanical equipment rooms and penthouses showing all related equipment and equipment clearances required by other trades.
2. Layout drawings of areas in which it may be necessary to deviate substantially from layout shown on the drawings. Minor transitions in ductwork, if required due to job conditions, need not be submitted as long as the duct area is maintained. Show major relocation of ductwork and major changes in size of ducts. Coordinate shop drawings with all trades prior to ductwork fabrication.
3. Details of intermediate structural steel members required to span main structural steel for the support of ductwork.
4. Method of attachment of duct hangers to building construction.
5. Duct material, gage, type of joints and duct reinforcing for each size range, including sketches or SMACNA plate numbers for joints, method of fabrication and reinforcing.

1.22 GUARANTEE

A. Furnish guarantee covering all work in accordance with general requirements of the contract for minimum period of one year. This personal guarantee shall exist for a period of one (1) year from the date of final acceptance of the work and shall apply to defects in materials and to defective workmanship of any kind.

B. For factory-assembled equipment and devices on which the manufacturers furnish standard published guarantees as regular trade practice, obtain such guarantees and replace any such equipment that proves defective during the life of these guarantees.

C. Guarantee all work for which materials are furnished, fabricated or field erected by the contractor, all factory-assembled equipment for which no specific manufacturer's guarantee is furnished, and all work in connection with installing manufacturer's guarantee is furnished, and all work in connection with installing manufacturer's guaranteed equipment.

D. In the event of failure of any work, equipment or device during the life of the guarantee, repair or replace the equipment or defective work. Remove, replace or restore, at no cost to the Owner, any part of the structure or building which may be damaged either as the direct result of the defective work or in the course of the contractor's making replacement of the defective work or materials. Work shall be done at a time and in a manner as to cause no undue inconvenience to the Owner. Provide new materials, equipment, apparatus and labor to replace that determined by Engineer to be defective or faulty.

E. This guarantee also applies to services including Instructions, Adjusting, Testing, Noise, Balancing, etc.

F. Additional equipment and material guarantees and warrantees may be indicated in other sections. In all cases, the more stringent guarantee or warrantee shall be provided.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT QUALITY

A. Material and equipment furnished under this Division of specification shall be new. Defective or inferior materials must be replaced by contractor at no cost to Owner regardless of the stage of construction. Inferior material shall be defined as material or equipment of a quality or performance less than that specified as determined by the Owner's Representative.

B. Provide each item of equipment with manufacturer's identification tag which is readily accessible and clearly shows model and size.

2.2 ACCESS TO MECHANICAL WORK

A. Access Doors:
   1. General: Where walls and ceilings must be penetrated for access to mechanical work, access doors shall be provided. Furnish adequate size for intended and necessary access. Furnish doors with UL Fire Rating to match wall or ceiling construction. Furnish manufacturer's complete units, of type recommended for application in indicated substrate construction, in each case, complete with anchorages and hardware.

B. Access Door Construction: Refer to Section 083113 – ACCESS DOORS AND FRAMES

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Tests:
   1. Perform as specified in individual sections, and as required by authorities having jurisdiction.
   2. Duration as noted.

B. Provide required labor, material, equipment, and connections.

C. Furnish written report and certification those tests have been satisfactorily completed.

D. Repair or replace defective work, as directed.

E. Pay for restoring or replacing damaged work due to tests as directed.

F. Pay for restoring or replacing damaged work of others, due to tests, as directed.

3.2 3.2 ACCESS TO MECHANICAL WORK

A. Coordinate installation and placement of access doors and panels with contractor for general construction.

B. Remove or replace panels or frames that are warped, bowed, or otherwise damaged.

END OF SECTION 230001

SECTION 230002 – MECHANICAL AND ELECTRICAL COORDINATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work Included in This Section: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Motors.
   2. Factory-wired equipment (FWE).
   3. Factory-wired control panels (FWCP).
   4. Motor controllers where provided as part of mechanical equipment.
   5. Motor controllers where supplied under Division 23 - Mechanical Work.
   6. Disconnects and safety switches for mechanical equipment.
   7. Fuses for equipment provided, and starters and disconnect switches.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Division 23 - HVAC Instrumentation and Controls, Motors.

B. Division 26 - Electrical: Installation and Power Wiring of Motor Controllers.

1.3 REFERENCE STANDARDS

A. Published specifications standards, tests, or recommended methods of trade, industry or governmental organization as apply to work in this section where cited below:
   1. ANSI - American National Standards Institute.
   2. NEMA - National Electrical Manufacturer's Association.
   3. IEEE - Institute of Electrical and Electronic Engineers.

1.4 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

B. Supply all equipment and accessories new and free from defects.

C. Supply all equipment and accessories in compliance with the applicable standards listed in Article 1.03 of this Section and with all applicable National, State and local codes.

D. All items of a given-type shall be the products of the same manufacturer.

1.5 DIVISION OF WORK

A. This section delineates the work required to be performed by Contractors under Divisions 23 and 26.

1.6 WORK REQUIRED UNDER DIVISION 23

A. Furnish motors, manual and combination starters, pushbutton devices, contactors, disconnect switches, electric thermostats, low voltage transformers, Emergency Break Glass Stations and other electrical devices required for equipment furnished.

B. Install all items in piping and ductwork such as control valves, aquastats, ductstats, etc.

C. All external wiring of equipment, all temperature control wiring, external wiring of control circuits of magnetic starters, interlocking wiring, boiler wiring, Emergency Break Glass Stations, and mounting of control devices, etc., shall be included under Division 23. All external wiring shall be in conduit. (Unless specifically shown to be provided by the Electrical Contractor)

D. The Electrical Contractor, under Division 26, shall furnish and install all power wiring and conduit to junction box, to disconnect switch on unit, to motor starters and contactors, and between motor starters and contactors to motor or other load. Electrical Contractor shall be responsible for proper direction of rotation for all three phase equipment. The Electrical Contractor shall mount all starters, disconnects.

E. Wiring required under Division 23 shall comply with the specifications as described in Division 26.

F. The Plumbing Contractor, under Division 22, shall provide water and natural gas services to within two (2) feet of HVAC equipment requiring same and terminating with shut-off valves. The HVAC Contractor, under Division 23, shall make final connections to equipment.

G. Provide disconnect switches or safety switches for equipment. (Unless specifically shown to be provided by the Electrical Contractor, starters and disconnects shown on the electrical drawings are for installation and do not require the Electrical Contractor to furnish units)

H. Emergency Generator - Exhaust muffler and flexible exhaust connection shall be furnished by the generator manufacturer under Division 26. Installation of the exhaust system including providing piping, insulation and accessories shall be included under Division 23.

1.7 SUBMITTALS

A. Shop Drawings: Complete wiring diagrams of all power and control connections (standard diagrams will not be accepted). Deliver 2 copies of approved wiring diagrams to the Electric Contractor for installation of wiring and connections required under the Electric Contract.

B. Product Data for Motor Controllers and Disconnect Switches: Manufacturer's catalog sheets, specifications and installation instructions. Submit enclosure type coordinated for service and location. Submit simultaneously with product data required for motors. Identify each controller for use with corresponding motor. Submit shop drawings and product data in accordance with project requirements.

C. All warranties shall be delivered as part of the close-out submission.

D. A receipt shall be delivered as part of the close-out submission that states all required spare parts have been delivered to the owner. This receipt must be signed and dated by the owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Motor Controllers and Disconnects
   1. Square D
   2. Allen-Bradley
   3. General Electric
   4. Cutler-Hammer

2.2 MOTOR CONTROLLERS

A. General: All starters shall be correctly sized to motor connected thereto. Provide one (1) additional auxiliary contact over and above that normally furnished, at least two (2) required.

Provide overload heaters for each phase. Coordinate starters and controllers with the temperature control Contractor and sequence of operations.

B. Minimum Size: The minimum allowable size of single or three phase magnetic motor controller is NEMA size 0.

C. Enclosures: Unless otherwise indicated furnish NEMA 1 enclosures, except where installed outdoors furnish NEMA 3R enclosures.

D. Control Power: Furnish control power transformer (maximum control voltage 120 volts) mounted within each magnetic motor controller enclosure.

E. Local Control Devices: Where indicated, furnish standard duty push buttons or 3-position hand-off-auto selector switch mounted in the controller enclosure.

F. Pilot Lights: Furnish pilot lights of the neon lamp type mounted in the controller enclosure, green for running, red for not running.

G. Motor Controller Types:
   1. Type A (Full Voltage, Manual, Non-Magnetic):
      a. Allen-Bradley Co. Bulletin 609 (or Bulletin 600 - single phase, 1 HP or less only).
      b. General Electric Co. CR-1062 (or CR-101 - single phase, 1 HP or less only).
      c. Square D Co. Class 2510, Type M (or Class 2510, Type F - single phase, 1 HP or less only).
      d. Cutler-Hammer. B100 (or MS - single phase, 1 HP or less only).
   2. Type A2 (2 Speed, 2 Winding, Full Voltage, Manual, Non-Magnetic):
      a. Allen-Bradley Co. Bulletin 609TS (or Bulletin 600 - single phase, 1 HP or less only).
      b. General Electric Co. CR-1062 (or CR-101 - single phase, 1 HP or less only).
      c. Square D Co. Class 2512, Type M (or Class 2512, Type F - single phase, 1 HP or less only).
   3. Type B (Full Voltage Magnetic):
      a. Allen-Bradley Co. Bulletin 709.
      b. General Electric Co. CR-206.
      c. Square D Co. Class 8536.
      d. Cutler-Hammer. ECN05.
   4. Type B-COM (Combination Full Voltage Magnetic/Safety Switch):
      a. Allen-Bradley Co. Bulletin 712.
      b. General Electric Co. CR-208.
      c. Square D Co. Class 8538.
      d. Cutler-Hammer. ECN16.
   5. Type B2 (2 Speed, 2 Winding, Full Voltage, Magnetic):
      a. Allen-Bradley Co. Bulletin 715.
      b. General Electric Co. CR209.
      c. Square D Co. Class 8810.
      d. Cutler-Hammer. ECN33.
   6. Type C (Automatic, Reduced Voltage, Magnetic):
      a. Allen-Bradley Co. Bulletin 746.
      b. General Electric Co. CR-231.
      c. Square D Co. Class 8606.
      d. Cutler-Hammer. ECA42.
   7. Type C-COM (Combination Automatic, Reduced Voltage, Magnetic/ Safety Switch):
      a. Allen-Bradley Co. Bulletin 746C.

b. Square D Co. Class 8606.
c. Cutler-Hammer. ECA43.

8. Type D (Part Winding, Magnetic):
   a. Allen-Bradley Co. Bulletin 736.
   b. General Electric Co. CR-230.
   c. Square D Co. Class 8640.
   d. Cutler-Hammer. ECA45.

2.3 REMOTE PUSH BUTTON STATIONS

A. Start-Stop with pilot light in NEMA 1 enclosure unless otherwise indicated.
   1. Allen-Bradley Co. Bulletin 800S.
   2. General Electric Co. CR-2943.
   3. Square D Co. Class 9001.
   4. Cutler-Hammer. Class 10250.

2.4 SAFETY SWITCHES

A. General Electric Co. Type TH; Square D Co. Heavy Duty Series; Cutler-Hammer HD Series; with the following:
   1. Fused or unfused as required.
   2. Fused switches equipped with fuseholders to accept only the fuses specified in Section 16181 (U.L. Class RK-1, RK-5, L).
   3. NEMA 1 enclosure unless otherwise indicated on drawing or required. 3R for devices installed outdoors.
   4. Switch rated 240V for 120V, 208V, 240V, circuits; 600 V for 277V, 480V circuits.
   5. Switch rated 600V for 277V, 480V circuits.
   6. Solid neutral bus when neutral or grounding conductor is included with circuit.
   7. Current rating and number of poles as indicated on drawings.

2.5 NAMEPLATES

A. Phenolic Type: Standard phenolic nameplates with 3/8" minimum size lettering engraved thereon.

B. Embossed Aluminum: Standard stamped or embossed aluminum tags: Tech Products, Inc., Seton Name Plate Corp.

PART 3 - EXECUTION

3.1 GENERAL

A. Equipment shall be connected in a neat and skillful manner. Equipment deliver with terminal boxes that are inadequate shall be equipped with special boxes that suit the conditions by the Mechanical Contractor furnishing the equipment.

B. In general, rigid conduit or tubing shall be used, but equipment that requires movement or that would transmit vibration to conduit shall be wired with flexible (liquid tight) steel conduit not over 18" long.

C. All equipment shall be grounded with a green-covered ground wire run inside the conduit and connected to equipment frame on one end and to grounding system on the other end.

D. All electrical work required in the Mechanical Contract shall conform to the applicable requirements of Division 26 of these Specifications.

E. The Heating, Ventilating, and Air Conditioning Contractor shall assign all Electrical Work required under his contract to the approved Automatic Temperature Control Contractor, who shall perform this work with qualified electricians employed by that Contractor.

F. The Mechanical Contractors shall cooperate with the Contractor for Electrical Work in making all necessary tests and in receiving, storing, and setting all motor-driven equipment, electrical devices, and controls furnished and/or installed under these contracts.

G. Install heaters correlated with full load current of motors provided.

H. Set overload devices to suit motors provided.

3.2 INSTALLATION

A. Control Wiring:
1. Provide control wiring and connections.
2. Where control circuit interlocking is required between individually mounted motor controllers, provide a single pole on-off switch in a threaded type box mounted adjacent to motor safety switches which are remote from the control transformer (to enable interlock circuit to be opened when the motor safety switch is opened).

B. Nameplates: Rivet or bolt the nameplate on the cover of NEMA 1 enclosures. Rivet or bolt and gasket the nameplate on cover of NEMA 3R or NEMA 12 enclosures. Provide phenolic or embossed aluminum nameplates as follows:
1. On each remote control station, indicating motor controlled.
2. On each interlock circuit switch, indicating purpose of switch.

3.3 TYPES OF MOTOR CONTROLLERS REQUIRED FOR SINGLE SPEED MOTORS (SYSTEMS UNDER 250 VOLTS)

A. Single Phase Motors Less than 1/2 HP - Automatically Operated: Type A.

B. Single Phase Motors 1/2 to 5 HP - Automatically Operated: Type B.

C. Three Phase Squirrel Cage Motors Less than 7-1/2 HP: Type B (B-COM when indicated on drawings).

D. Three Phase Squirrel Cage Motors 7-1/2 HP and Larger: Type C (C-COM when indicated on drawings).

E. Three Phase Hermetically Sealed Compressor Motors Less than 7-1/2 HP: Type B.

F. Three Phase Hermetically Sealed Compressor Motors 7-1/2 HP and Larger: Type D.

3.4 TYPES OF MOTOR CONTROLLERS REQUIRED FOR 2 SPEED MOTORS (SYSTEMS UNDER 250 VOLTS)

A. Single Phase Motors Less than 1/2 HP - Automatically Operated: Type A2.

B. Single Phase Motors 1/2 to 5 HP - Automatically Operated: Type B2.

C. Three Phase Squirrel Cage Motors Less than 7-1/2 HP: Type B2.

3.5 DISCONNECTS

A. Motor Controllers: Provide safety switch for all motor controllers. Provide combination type starter-disconnect unless otherwise noted on drawings.

B. Motors: Provide a disconnect switch for all motors. Provide a separate safety switch for motors which are not within sight of the starter.

C. Provide safety switches for all factory packaged equipment.

D. Provide NEMA 3R safety switch for all rooftop and outdoor equipment.

E. Provide unit mounted disconnect switches for all equipment such as unit heaters, fans, unit ventilators, incremental units, etc

END OF SECTION 230002

SECTION 230130 - HVAC AIR-DISTRIBUTION SYSTEM CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

B. Provide labor, materials, equipment and services required to thoroughly clean the HVAC / ductwork systems as designated in the Contract Documents.

C. Provide all labor, material, and services to obtain access to HVAC systems to be cleaned including:
   1. Removal and reinstallation of ceiling systems
   2. Cutting and patching of wall and ceiling systems

1.2 QUALITY ASSURANCE

A. The duct system shall be free of construction debris.

B. New HVAC ductwork system installations shall comply with level “B”, the Intermediate Level of SMACNA Duct Cleanliness for New Construction.

C. Existing HVAC ductwork system cleaning shall comply with The NADCA Standard for Assessment Cleaning & Restoration of HVAC Systems 2013 (ACR-2013), as published by the National Air Duct Cleaners Association.

D. The Duct Cleaning Contractor or subcontractor shall be a member of the National Air Duct Cleaners Association (NADCA) and shall have at least two certified Air Systems Cleaning Specialists (ASCS) on regular staff, two years of experience in this field. The Contractor shall produce a reference list to the Owner and Project Engineer of projects successfully completed of a similar size and scope.

E. Supervisor qualifications: The project shall be supervised by an ASCS at all times.

1.3 SUBMITTALS TO THE ARCHITECT/ENGINEER

A. Provide MSDS sheets on all solvents, cleaners, microbial reduction agents, and disinfectants to be used on project.

B. Contractor credentials, including NADCA certificates, project references, and cleaning methods and application methods for microbial reduction agents and coatings.

1.4 SUBMITTALS TO THE OWNER

A. Since the systems must be operational during the normal work hours, the Contractor shall submit to the Owner a procedure for cleaning the ductwork and installing filters which will minimize contamination of already cleaned areas. This sequence must be approved by the Owner and Project Engineer prior to starting work

PART 2 - PRODUCTS

2.1 MICROBIAL REDUCTION AGENTS

A. Microbial reduction agents shall only be applied if active fungal growth is reasonably suspected, or where an unacceptable level of fungal contamination has been verified through testing.

B. All products for application on non-porous surfaces inside HVAC / ductwork systems shall have an E.P.A. registration specifically for this application.

2.2 COATING FOR POROUS (FIBERGLASS LINED) COMPONENTS

A. A mechanical insulation repair coating, Tough Coat, as manufactured by Vac System Industries, Inc., or approved equal shall be used. The coating material shall contain an anti-microbial agent, shall not affect the thermal or acoustic properties of the insulation, and shall conform to NFPA Standards 90A and 90B.

2.3 PLENUM PAINT

A. Porous Surface: The paint shall be Porta-Sept as manufactured by Porter Paints, Inc., or approved equal. Paint shall contain an EPA registered anti-microbial preservative known as Intersept, which inhibits the growth of bacteria, mold, mildew, and fungi.

PART 3 - EXECUTION

3.1 HEALTH AND SAFETY

A. Cleaning contractors shall comply with all applicable federal, state and local requirements for protecting the safety of the contractors' employees, building occupants, and the environment. In particular, all applicable standards of the Occupational Safety and Health Administration (OSHA) should be followed when working in accordance with this standard.

B. No processes or materials shall be employed in such a manner that they will create adverse health effects to the building occupants, cleaning contractors, or general public.

C. Disposal of Debris. All debris removed from the ACS shall be disposed of in accordance with all applicable federal, state, and local requirements.

3.2 PREPARATION

A. Prior to start of work, the HVAC system is to be carefully inspected and checked for all conditions affecting the cleaning. Defects are to be reported in writing to the Project Engineer and work will not proceed until all defects have been documented. Commencement of work will constitute acceptance of the conditions of the area to which the cleaning work is to be performed and all defects in work resulting from such accepted service will be corrected by this trade without additional expense to the Owner. No cleaning is to be performed to ducts where the process has the capability of damaging the duct lining. The decision to clean and/or encapsulate these areas will be made by the Project Engineer after review of the Contractor's findings and the Project Engineer has seen the field conditions.

B. Disassemble all removable items as required for access to work area. Store the removables in a Project Engineer or Owner approved storage area until the completion of the cleaning work.

C. Fire protection devices (such as smoke detectors, panels, etc.) shall be protected prior to cleaning procedures. They are to be cleaned and tested at the conclusion of work.

D. The Contractor shall coordinate the shutdown and reactivating of the fire alarm system to avoid accidental alarms during the cleaning process and related work.

E. The Contractor shall coordinate the shutdown of the air handling equipment with the Owner before starting work, and shall conform to OSHA requirements regarding fan motor disconnect lock-out/tag-out.

F. Report to Project Engineer any system defects discovered during the cleaning operation which will require repair to an HVAC system component that is outside of the scope of work as specified herein. Any defects should be identified in a 'Conditions Found Report'.

3.3 GENERAL REQUIREMENTS

A. Mechanical Cleaning Methodology:
   1. Comply with NADCA ACR 2006.
   2. Cleaning methods shall be employed such that all Non-Porous surface components must be Visibly Clean (per section 13 of ACR-2006).
   3. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.
      a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
      b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.
   4. Cleaning Mineral-Fiber Insulation Components:
      a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
      b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
      c. Fibrous materials that become wet shall be discarded and replaced.

B. Containment: Debris removed during cleaning shall be collected and precautions must be taken to ensure that debris is not otherwise dispersed outside the ACS during the cleaning process. After ACS cleaning, any areas which could be affected by the cleaning contractor's work must be as clean as their condition prior to the commencement of the cleaning operation.

C. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

D. Particulate Collection.
   1. Where the Particulate Collection Equipment is exhausting inside the building, HEPA filtration with 99.97% collection efficiency for 0.3-micron size particles shall be used (See EPA's Building Air Quality).
   2. When the Particulate Collection Equipment is exhausting outside the building, Mechanical cleaning operations shall be undertaken only with Particulate Collection Equipment in place, including adequate filtration to control debris removed from the ductwork or ceiling plenum. When the Particulate Collection Equipment is exhausting outside the building, precautions shall be taken to ensure that exhausted air does not re-enter the building.

E. Controlling Odors. Control odors and mist vapors during the cleaning and restoration process. All reasonable measures shall be taken to control offensive odors and/or mist vapors during the cleaning process.

F. Air-Volume Control Devices. Dampers and any air-directional mechanical devices inside the ductwork must have their position marked prior to cleaning and, upon completion, must be restored to their marked position.

G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

3.4 SYSTEMS AND COMPONENTS:

A. Ductwork Systems:
   1. Applies to:
      a. Return-air ducts to the air-handling unit.
   2. Mechanically clean ductwork systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests in accordance with the NADCA standard, ACR 2006.
   3. No cleaning method should be used which could potentially damage components of the ductwork or negatively alter the integrity of the system.
   4. Mechanical cleaning and agitation methods shall be capable of cleaning minimum 50 foot sections of ductwork in each direction per access point so as to minimize the number of service openings and thus preserve the integrity of the ductwork and minimize leakage. The agitation tool shall be required to contact all sides of the duct regardless of size and configuration. The Contractor shall produce a detailed description of procedures and methods to the Engineer/Owner.
   5. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of ducts so areas being cleaned are under negative pressure.
   6. Where ductwork is large enough and able to support the weight of a worker, hand tools and HEPA shop vacs may be used. If workers enter the inside of the duct they must follow the OSHA confined space requirements (OSHA 29 CFR 1910.146) Collection equipment must be used during this process to assure capture of any residual or airborne debris.
   7. Clean fibrous-glass duct liner with HEPA vacuuming equipment, or other methods without damaging the integrity of the duct liner. Apply mechanical insulation repair coating to fiberglass lined surfaces in ductwork and air handlings units after cleaning. Replace fibrous-gall ductliner that is severely damaged, deteriorated, mold infested or wet.

3.5 CLEANLINESS VERIFICATION

A. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.

B. Verification of cleanliness will be determined after Mechanical Cleaning and before the application of any treatment or introduction of any treatment-related substance. Verification of Non-Porous Surface Cleaning and Verification of Coil Cleaning shall be conducted after Mechanical Cleaning and before the system is restored to normal operation.

C. Verification of Non-Porous Surface Cleaning:
   1. All Non-Porous Interior Duct/Air Handling Unit Surfaces must be Visibly Clean.
   2. An interior surface is considered visibly clean when it is free from non-adhered substances and debris.
   3. Where contaminants are discovered, re-clean and re-inspect duct systems.

4. In the event there is a discrepancy with regard to if the surface is visibly clean, contractor shall conduct Surface Comparison Testing per Section 13.2 of the NADCA ACR-2006.
5. Photo documentation of representative sections and components of cleaned systems shall be provided by the Contractor.

D. Verification of Coil Cleaning:
1. Mechanical Cleaning must restore the Coil-Pressure Drop to within 10 percent of the Pressure Drop measured when the Coil was first installed. If original pressure drop is not known, the coil will be considered clean based on visual inspection.

3.6 MICROBIAL REDUCTION AGENT APPLICATION

A. A microbial reduction agent shall be applied to all supply and return air metal only ductwork cleaned as part of this project. Application and preparation shall be as per manufacturer's recommendations.

B. The Contractor must demonstrate to the Project Engineer how the application method is capable of dispensing the sanitizing solution to the entire surface areas of the ductwork.

3.7 RESTORATION

A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.

B. Comply with Division 23 Sections "Metal Ducts" and Air Duct Accessories" for duct materials, accessories, and hardware required for Work of this Section.

C. Ensure that closures do not hinder or alter airflow.

D. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

E. Reseal fibrous-glass ducts. Comply with requirements in Division 23 Section "Nonmetal Ducts."

3.8 POST PROJECT REPORT

A. Prepare a written cleanliness verification report. At a minimum, include the following:
1. Written documentation of the success of the cleaning.
2. Site inspection reports.
3. Photographic Documentation.
4. Areas of the system found to be damaged, in need of repair, and / or requiring more aggressive cleaning.

END OF SECTION 230130

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SECTION 230513 - 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.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

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

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

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

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium energy 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. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. 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.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

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

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

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

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

PART 3 - EXECUTION (Not Used)

END OF SECTION 230513

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

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

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

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

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

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. CALPICO, Inc.
   3. Metraflex Company (The).
   4. Pipeline Seal and Insulator, Inc.
   5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

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

2.5 GROUT

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

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

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

D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.4 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-sheet.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

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

2.2 FLOOR PLATES

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for exposed piping penetrations of walls, ceilings, finished floors, and millwork, except in mechanical equipment rooms or unoccupied areas.

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

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

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

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518

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SECTION 230519 - METERS AND GAGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Duct-thermometer mounting brackets.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Test-plug kits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers:
1. Ashcroft Inc.
2. Nanmac Corporation
3. Tel-Tru Manufacturing Company
4. Trerice
5. Weiss Instuments, Inc.

B. Standard: ASME B40.200.

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

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

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

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

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

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Manufacturers:
   a. Trerice
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch nominal size.
4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass.
8. Stem: Aluminum or brass and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
9. Connector: 3/4 inch, 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.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Manufacturers:
   a. Tel-Tru Manufacturing Company
   b. Trerice
   c. Weiss Instruments Inc.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass.
8. Stem: Aluminum 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, 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 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

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

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

2.5 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers:
   a. Ametek U.S. Gauge
   b. Ashcroft Inc.
   c. Tel-Tru Manufacturing Company
   d. Trerice
   e. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4, 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 and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

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

2.7 TEST PLUGS

A. Manufacturers:
1. Flow Design, Inc.
2. Trerice

3. Watts
4. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion in 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 1/2, ASME B1.20.1 pipe thread.

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

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

A. Manufacturers:
1. Flow Design, Inc.
2. Trerice
3. Watts
4. Weiss Instruments, Inc.

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

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

D. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least 0 to 100 psig.

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches 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 duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

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

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

I. Install test plugs in piping tees.

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

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

L. Install thermometers in the following locations:
1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Inlet and outlet of each hydronic coil in air-handling units.
4. Return-air and supply-air ducts.

M. Install pressure gages in the following locations:
1. Discharge of each pressure-reducing valve.
2. Suction and discharge of each pump.
3. Inlet and outlet of each hydronic coil in air-handling units.

3.2 CONNECTIONS

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

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

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

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F and 0 to 150 deg C.

B. Scale Range for Air Ducts: 0 to 150 deg F and minus 20 to plus 70 deg C.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi and 0 to 600 kPa.

END OF SECTION 230519

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SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Bronze ball valves.
2. Iron ball valves.
3. Iron, single-flange butterfly valves.
4. Iron, grooved-end butterfly valves.
5. Bronze swing check valves.
6. Bronze, grooved-end butterfly valves.
7. Iron swing check valves.
8. Iron, grooved-end swing-check valves.
9. Iron, grooved-end spring-loaded check valves.
10. Bronze gate valves.
11. Iron gate valves.
12. Bronze globe valves.

B. Related Sections:
1. Section 230553 "Identification for HVAC 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 ACTION 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. To assure uniformity and compatibility, all grooved end valves and adjoining couplings shall be supplied by a single manufacturer.

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 HVAC 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 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
5. 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 stem extensions and the following features:
1. Gate Valves: With rising stem.
2. 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.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:
1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
   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. Lance Valves; a division of Advanced Thermal Systems, Inc.
      e. Milwaukee Valve Company.
      f. NIBCO INC.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      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, vented.
      j. Port: Full.

2.3 IRON BALL VALVES

A. Class 125, Iron Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Conbraco Industries, Inc.; Apollo Valves.
      c. Kitz Corporation.
      d. Sure Flow Equipment Inc.
      e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-72.
      b. CWP Rating: 200 psig.
      c. Body Design: Split body.
      d. Body Material: ASTM A 126, gray iron.
      e. Ends: Flanged.
      f. Seats: PTFE or TFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel.
      i. Port: Full.

B. 800 CWP, Ductile Iron Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic.
   2. Description:

a. Standard: Meets the Intent of MSS SP-72.
b. CWP Rating: 800 psig.
c. Body Design: Split body.
d. Body Material: ASTM A 396, ductile iron.
e. Ends: Grooved.
f. Seats: TFE.
g. Stem: Chrome-plated carbon steel.
h. Ball: Chrome-plated carbon steel.
i. Port: Standard.

2.4 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Jenkins Valves.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Flo Fab Inc.
h. Hammond Valve.
i. Kitz Corporation.
j. Legend Valve.
k. Milwaukee Valve Company.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

2.5 IRON, GROOVED-END BUTTERFLY VALVES

A. 300 CWP, Iron, Grooved-End Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Kennedy Valve; a division of McWane, Inc.
b. Tyco Fire Products LP; Grinnell Mechanical Products.
c. Victaulic Company.
2. Description:
a. Standard: MSS SP-67, Type I.
b. CWP Rating: 300 psig.

c. Body Material: Coated, ductile iron.
d. Stem: Two-piece stainless steel.
e. Disc: Coated, ductile iron.
f. Seal: EPDM or PPS coated
g. Design: Offset disc providing continuous 360 degree seating.

2.6 BRONZE, GROOVED END BUTTERFLY VALVES

A. 300 CWP, Bronze, Grooved-End Butterfly 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. Victaulic.
2. Description:
a. Standard: Meets or Exceeds MSS SP-67.
b. CWP Rating: 300 psig.
c. Body Material: Bronze.
d. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
e. Disc: Aluminum-bronze.
f. Seal: Fluoroelastomer.

2.7 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Non-metalic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Zy-Tech Global Industries, Inc.
2. Description:
a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Non-metalic.

2.8 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Composition.
   h. Seat Ring: Bronze.
   i. Disc Holder: Bronze.
   j. Disc: PTFE or TFE.
   k. Gasket: Asbestos free.

2.9 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Tyco Fire Products LP; Grinnell Mechanical Products.
      c. Victaulic Company
   2. Description:
      a. CWP Rating: 300 psig.
      b. Body Material: ASTM A 536, ductile iron.
      c. Seal: EPDM.
      d. Disc: Spring operated, ductile iron or stainless steel.

2.10 IRON, GROOVED-END SPRING-LOADED CHECK VALVES

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. Victaulic Company

B. Description:
   1. NPS 2 to NPS 3: 365 psig CWP.
   2. NPS 4 to NPS 12: 300 psig CWP.
   3. NPS 14 to NPS 24: 230 psig CWP.
   4. Body Material: ASTM A 536 ductile iron.
   5. Seat: Plated nickel surface, welded-in nickel alloy, or EPDM.
   6. Disc: Stainless steel or EPDM coated ductile iron

2.11 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hammond Valve.
      b. Kitz Corporation.
      c. Milwaukee Valve Company.
      d. NIBCO INC.
      e. Powell Valves.
      f. Red-White Valve Corporation.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

B. Class 150, RS Bronze Gate 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; Stockham Division.
   c. Hammond Valve.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   i. Zy-Tech Global Industries, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.12 IRON GATE VALVES

A. Class 125, NRS, Iron Gate 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. Crane Co.; Crane Valve Group; Stockham Division.
   d. Flo Fab Inc.
   e. Hammond Valve.
   f. Kitz Corporation.
   g. Legend Valve.
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell Valves.
   k. Red-White Valve Corporation.
   l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   m. Zy-Tech Global Industries, Inc.
2. Description:
   a. Standard: MSS SP-70, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate 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. Crane Co.; Crane Valve Group; Stockham Division.
d. Flo Fab Inc.
e. Hammond Valve.
f. Kitz Corporation.
g. Legend Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Powell Valves.
k. Red-White Valve Corporation.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
m. Zy-Tech Global Industries, Inc.
2. Description:
a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.13 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Red-White Valve Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Zy-Tech Global Industries, Inc.
2. Description:
a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.

d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.14 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
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. Nordstrom Valves, Inc.
2. Description:
a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short.
f. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
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. Nordstrom Valves, Inc.
2. Description:
a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short.
f. Plug: Cast iron or bronze with sealant groove.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.

F. Grooved end valves shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved end valves and adjoining couplings shall be the products of a single manufacturer. Grooved end shall be clean and free from indentations and projections in the area from pipe end to groove for proper gasket sealing. A factory-trained field representative shall provide on-site training for contractor's field personnel in the installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

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, butterfly or gate valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Throttling Service except Steam: ball valves.
   4. Pump-Discharge Check Valves: Refer to division “Hydronic Pumps.”

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 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
   3. For Steel Piping, NPS 5 and Larger: Flanged ends.
   4. For Grooved-End Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
   3. Bronze Swing Check Valves: Class 150, bronze disc.
   4. Bronze Gate Valves: Class 150, bronze.
   5. Bronze Globe Valves: Class 150, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. Iron Swing Check Valves: Class 125, metal seats.
6. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
7. Iron Gate Valves: Class 125, OS&Y.
8. Lubricated Plug Valves: Class 125, regular gland, threaded or flanged.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. BronzeValves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, nonmetallic disc.
4. Bronze Gate Valves: Class 150, bronze.

B. Pipe NPS 2-1/2 and Larger:
1. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. Iron Swing Check Valves: Class 125, nonmetallic-to-metal seats.
6. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
7. Iron Gate Valves: Class 125, OS&Y.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Metal framing systems.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

B. Related Sections:
1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 233113 "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.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Metal framing systems.
2. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

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

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

2.2 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 carbon steel.
7. Metallic Coating: Galvanized.
8. Paint Coating: Epoxy.

B. Non-MFMA Manufacturer Metal Framing Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International; a subsidiary of Mueller Water Products Inc.
   b. Empire Industries, Inc.

c. ERICO International Corporation.
d. Haydon Corporation; H-Strut Division.
e. NIBCO INC.
f. PHD Manufacturing, Inc.
g. 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.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Coating: Paint.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping:
1. ASTM C 552, Type II cellular glass with 100-psigminimum compressive strength and vapor barrier.
2. ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping:
1. Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psigminimum compressive strength.
2. ASTM C 552, Type II cellular glass with 100-psigminimum compressive strength.
3. ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

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

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

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

2.4 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, 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 EQUIPMENT SUPPORTS

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

2.6 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, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

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

D. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

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

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

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

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

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

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

L. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.

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

3.4 ADJUSTING

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

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

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

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

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
   3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
   4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
   6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
9. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
10. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
11. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
12. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
13. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
14. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
15. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
16. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
17. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
18. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
19. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

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

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.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

END OF SECTION 230529

SECTION 230548 - VIBRATION ISOLATION

PART 1 GENERAL

1.01 DEFINITIONS

A. Ground Floor: Floor or floor slab of building resting directly on earth.

1.02 SUBMITTALS

A. Waiver of Submittals: The "Waiver of Certain Submittal Requirements" in Section 013300 does not apply to this Section.

B. Shop Drawings:
1. Details of intermediate structural steel members and method of attachment required for installation of vibration isolating devices.
2. Design Calculations: Calculations for selection of vibration isolators, design of vibration isolation bases, and selection of seismic restraints.
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.

C. Product Data:
1. Catalog sheets, specifications, and installation instructions.
2. Vibration isolator schedule showing usage.

PART 2 PRODUCTS

2.01 MANUFACTURERS/COMPANIES

A. Amber-Booth Co.

B. Korfund Dynamics Corp.

C. Mason Industries Inc.

D. Vibration Eliminator Co., Inc.

E. Vibration Mountings and Controls, Inc.

2.02 RUBBER-IN-SHEAR ISOLATORS

A. Provide molded mound shaped rubber or neoprene elements designed to provide the required deflection under imposed load. Furnish isolators properly housed, with steel top plate and base plate completely imbedded in rubber or neoprene, for bolting to equipment and foundations, of type as follows:
1. Single Rubber-In-Shear: Single element designed for static deflection of 1/4 inch.

2. Double Rubber-In-Shear: Two single elements assembled in series, to provide for a static deflection of 1/2 inch.

2.03 STEEL SPRING ISOLATORS

A. Types:
1. Free Standing Springs: Provide laterally stable units, without housing, with a minimum 1/4 inch thick rubber or neoprene sound deadening pad between spring and its support. Use for isolating equipment having a static deflection in excess of 1 inch, unless otherwise indicated.
2. Housed Springs: Provide units with telescoping cast iron or steel housings, containing one or more springs, complete with resilient alignment inserts and a minimum 1/4 inch thick rubber or neoprene sound deadening pad bonded to the base of housing.

B. Construction Features Required:
1. Provide limit stops for spring isolators with deflections of 2 inch or more so as to prevent undue motion during start and stop, but unrestrained movement during normal operation.
2. Hot dip galvanize all steel parts of isolators for outdoor use, with the exception of springs. Cadmium plate or neoprene coat springs.
3. Do not use isolator leveling bolts for jacking screws.

2.04 INTEGRAL STRUCTURAL STEEL OR RAIL TYPE BASES

A. Provide bases, factory fabricated from structural steel members of sufficient rigidity to maintain drive alignment and resist starting torque, without the use of restraining snubber devices. Provide bases complete with rubber-in-shear or spring type isolators, as specified for the particular equipment.

2.05 COMBINATION RUBBER AND SPRING ISOLATORS

A. Type: Combination rubber and spring type designed for insertion in a split hanger rod for isolating equipment from the overhead construction.
1. Approved isolators: Amber Booth Type BSSR, Korfund Type VX, Mason Industries, Type DNHS, Vibration Eliminator Co. Type SNRC and Vibration Mountings and Controls Type RSH.

2.06 PAD TYPE ISOLATORS

A. Provide neoprene or rubber mountings, corrugated or waffle faced both sides, single or double layered or laminated, or size and thickness as specified for the particular equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Jack equipment bases or inertia bases into position and block or wedge before springs are loaded. After equipment is bolted in place and springs are loaded, by means of the leveling bolts, remove the temporary blocking or wedging.

B. Housekeeping Pads:
   1. Coordinate size and location of pads with the Work of related contracts.
   2. Coordinate house keeping pads with restraint manufacturer to provide minimum edge distance of 10 bolt diameters around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings.
      a. If cast-in anchors are being used, size housekeeping pads in accordance with ACI requirements for bolt coverage and embedment.

C. Vibration Isolation Bases:
   1. Coordinate size and location of bases with the Work of related contracts.

3.02 APPLICATION

A. Provide vibration isolators or vibration isolation bases for mechanical equipment, piping and high velocity ductwork of type as specified.

B. Select isolation devices for uniform static deflection, in accordance with the distribution of weight and forces.
   1. Whenever rotational speed is the cause of disturbing frequency, utilize the lowest operating speed of the equipment in determining the type of isolation required.
   2. Selection shall result in uniform loading and deflection, even when equipment weight is not evenly distributed.
   3. Select springs for a total deflection greater than the selected static deflection, to provide an adequate safety factor.

C. Isolate floor mounted fan units, air handling units and self-contained air conditioning units, (with the exception of utility sets, fan units with wheels less than 27 inches and all equipment mounted on the ground floor), to obtain the following efficiencies:

RPM	MINIMUM DEFLECTION	EFFICIENCY
Up to 325	3.5	80
326 to 525	2.0	80-90*
526 to 575	1.5	90
576 to 1000	1.25	90-95*
1001 to 1200	.75	95
1201 and over	.50	95

*Lower efficiency at lowest RPM - higher efficiency at highest RPM.

3.03 VIBRATION ISOLATION SCHEDULE

A. Fans and Air Handling Units:
   1. Equip fans and air handling units, located above the ground floor and not indicated to be provided with a concrete inertia block or be ceiling mounted or suspended with vibration elimination equipment as follows:
      a. Provide an integral structural steel base with a common steel member running the full length of the fan and motor, with built-in motor slide rails, so as to form a common support for fan unit and motor, with spring type isolators, unless otherwise indicated.
      b. Provide spring unit isolators, or steel rail type isolator bases with spring type isolators, for floor mounted units with motors mounted on the casings or frames.
   2. Equip fans and handling units located on the ground floor, with the exception of medium or high pressure units not specified to be provided with a concrete inertia block, or be ceiling mounted or suspended, with unit isolators or steel rail type isolator bases.
   3. Floor Mounted Utility Fan Sets:
      a. Provide unit isolators or steel rail type isolator bases.
      b. Utility Sets with Overhung Scrolls: Provide steel rail type isolator bases, with built-in reaction units to compensate for overhang.
   5. Ceiling Suspended Fans and Air Handling Units: Provide combination rubber and spring type isolators, designed for insertion in a split hanger rod. Provide isolators with an efficiency as specified under the paragraph entitled “APPLICATION” of this Section, with no deflection greater than 1-1/2 inches required.

F. Remote Installed Refrigerant Compressor Units, Self Contained Belt Driven or Direct Driven Condensing Units and Floor Mounted Product Coolers: Provide steel rail type bases with built-in, metal housed, rubber-in-shear unit isolators, permanently fixed in place and provided with adjustable snubber devices. Provide rail bases on Ground Floor designed for 1/4 inch static deflection and above Ground Floor 1/2 inch static deflection.

G. Ceiling Suspended Product Coolers: Provide combination rubber and spring type isolators, designed for insertion in a split hanger rod. Provide isolators with an efficiency as specified under the paragraph entitled “APPLICATION” of this section, with no deflection greater than 1-1/2 inch required.

3.04 FIELD QUALITY CONTROL

A. Provide equipment and apparatus required for performing inspections and tests.
   1. Notify Director’s Representative a minimum of 14 days prior to equipment sound, vibration, and seismic testing.
   2. Rebalance, adjust, or replace equipment with noise or vibration levels in excess of those given in the equipment specifications, or equipment manufacturer's data.

B. Field Inspections:

1. Prior to initial operation, inspect the vibration isolators and seismic snubbers for conformance to drawings, specifications, and manufacturer's data and instructions.
   a. Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls.
   b. Check connector alignment before and after filling of system and during operation.
   c. Correct misalignment without damage to connector and in accordance with manufacturer's recommendations.

C. Spring Isolator Inspection
1. After installation of spring isolators or protected spring isolators, and seismic restraint devices, the equipment shall rock freely on its spring isolators within limits of stops or seismic restraint devices. Eliminate or correct any interferences.

D. Tests
1. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.
2. Equipment Vibration Tests
   a. Perform vibration tests to determine conformance with vibration isolation schedule specified.

END OF SECTION

SECTION 230550 - WIND RESTRAINT FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES

A. Support and brace mechanical and electrical systems, as called for, to resist directional wind forces (lateral, longitudinal and vertical).

1.3 APPLICABLE CODES AND STANDARDS

A. Provide work in compliance with the following codes and standards:

B. 2020 New York State Building Code (Section 1609).

C. 2020 New York State Mechanical Code (Section 301, Item 301.15).

D. American Society of Civil Engineers (ASCE) Minimum Design Loads for Buildings and Other Structures with Supplement No. 1 - Standard ASCE/SEI 7-16.

1.4 QUALITY ASSURANCE

A. General:
   1. The contractor shall provide professional engineer stamped and signed calculations, and details of wind restraint systems to meet total design lateral force requirements for support and restraint of mechanical and electrical systems.
   2. Systems requiring wind restraint including, but not limited to:
      a. Exhaust fans.
      b. Hooded intake or relief ventilators.
      c. Ductwork.
      d. Rooftop air handling equipment.
      e. Condensing units.
      f. Miscellaneous HVAC equipment.
      g. Roof curbs and pipe/duct/equipment supports associated with any of the equipment listed above.

1.5 SUBMITTALS

A. Submit wind force level (Fp) calculations from applicable building code. Submit pre- approved restraint selections, installation details, and plans indicating locations of restraints.

B. Calculations, plans, restraint selection, and installation details shall be stamped and signed by a professionally licensed engineer experienced in wind restraint design.

C. Submit manufacturer's product data.

D. For each piece of equipment that requires wind restraint as outlined in this section, include the following:
   1. Dimensioned Outline Drawings of Equipment Unit: Identify the center of gravity and locate and describe mounting and anchoring provisions.
   2. Anchorage: Provide detailed description of equipment anchorage devices on which the calculations are based and their installation requirements. Identify anchor bolts, studs and

other mounting devices. Provide information on the size, type and spacing of mounting brackets, holes and other provisions.

PART 2 - PRODUCTS

2.1 CODE INFORMATION

A. This project is subject to the wind bracing requirements of the 2020 New York State Building Code (Section 1609) and American Society of Civil Engineers ASCE/SEI 7-16. The following criteria are applicable to this project:
   1. Nominal Design Wind Speed (V) (Per ASCE 7-16): 120 mph.
   2. Risk Category (Per ASCE 7-16): III
   3. Exposure Category (Per ASCE 7-16): C
   4. Height and Exposure Adjustment Coefficient (Per ASCE 7-16): 1.21

2.2 WIND BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:
   1. Design analysis shall include calculated dead loads, wind loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
   2. Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
   3. All wind restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 2.1.

B. Friction from gravity loads shall not be considered resistance to wind forces.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wind Restraint of Electrical Services:
   1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines manual and all certified data.
   2. Installation of restraints shall not cause any change in position of equipment or piping, resulting in stresses or misalignment.
   3. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
   4. Do not install any equipment, piping, duct, or conduit that makes rigid connections with the building unless isolation is not specified.
   5. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
   6. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult Structural Engineer of record.
   7. Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The Contractor shall submit loads to the structural engineer of record for approval in this event.
   8. Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
   9. Provide reinforced clevis bolts where required.
   10. Do not brace a system to two independent structures such as a roof and wall.

B. Wind Restraint of Ductwork and Equipment:

1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines and all certified submittal data.
2. The interaction between mechanical and electrical equipment and the supporting structures shall be designed into the restraint systems.
3. Friction clips shall not be used for anchorage attachments.
4. Expansion anchors shall not be used for non-vibration isolated equipment rated over 10 HP.
5. Components mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction and vertical restraints shall be provided to resist overturning.
6. Installation of restraints shall not cause any change in position of equipment or ductwork, resulting in stresses or misalignment.
7. Exhaust fans with hinge kits shall have wind restraint fasteners installed on the hinged side, same as the three (3) non-hinged sides.
8. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
9. Do not install any equipment or duct that makes rigid connections with the building unless isolation is not specified.
10. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
11. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult Structural Engineer of record.
12. Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The Contractor shall submit loads to the Structural Engineer of record for approval in this event.
13. Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
14. Provide reinforced clevis bolts where required.
15. Do not brace a system to two independent structures such as a roof and wall.

END OF SECTION

SECTION 230553 - 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 ACTION SUBMITTALS

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

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

C. Valve numbering scheme.

D. 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. Metal Labels for Equipment:
1. Material and Thickness: Aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch 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.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch 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 thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Red.

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

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

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

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, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

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

D. 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 high.

2.4 DUCT LABELS

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

B. Self-Adhesive Duct Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Duct Label 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 high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

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

2.7 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.
   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. 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 A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.
   2. Stencil Paint: Use for pipe marking.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:
   1. Heating Water Piping:
      a. Background Color: White.
      b. Letter Color: Black.
   2. Refrigerant Piping:
      a. Background Color: Black.
      b. Letter Color: Yellow.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
   4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1

inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 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. All services: 1-1/2 inches round.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

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SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.
   2. Balancing Hydronic Piping Systems: Field verify existing system.
      a. Constant-flow hydronic systems.
      b. Variable-flow hydronic systems.
      c. Primary-secondary hydronic systems.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 45 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. Certified TAB reports.

D. Sample report forms.

E. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 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. 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.

C. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.
1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. 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.

3.3 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, or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
1. Comply with requirements in ASHRAE 62.1, 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 Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping 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.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. 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 Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.
    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
2. Measure fan static pressures as follows to determine actual static pressure:
    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Report the cleanliness status of filters and the time static pressures are measured.
4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC 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.

3.6 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.

3.7 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
   1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
      a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Engineer and comply with requirements in Section 232123 "Hydronic Pumps."
   2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
      a. Monitor motor performance during procedures and do not operate motors in overload conditions.
   3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
   4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.9 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.10 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.

E. Check settings and operation of safety and relief valves. Record settings.

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: 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 electric heating coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load and at each incremental stage.
   5. Calculated kilowatt at full load.
   6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Airflow.
   3. Air pressure drop.
   4. Inlet steam pressure.

D. 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 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate-drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.
   8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.

4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.15 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.16 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.

3.17 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 and steam 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, and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches.

j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
   a. Total air flow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches wg.
   g. Cooling-coil static-pressure differential in inches wg.
   h. Heating-coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   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 o.c.
   f. Make and model number.
   g. Face area in sq. ft..
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.

n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.
2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

H. 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.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

I. Air-Terminal-Device Reports:
1. Unit Data:
a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.

g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm.
b. Air velocity in fpm.
c. Preliminary air flow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final air flow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

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.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

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.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.
2. Test Data (Indicated and Actual Values):
a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.

d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

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.

3.18 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Engineer.
2. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
3. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
4. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.19 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

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SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:
1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Related Sections:
1. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

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

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

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

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

F. Expanded Polystyrene Insulation: Closed-cell, light-weight, resilient, foamed plastic composed of hydrogen and carbon.
   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. Knauf Polystyrene.

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 III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Friendly Feel Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; SOFTR All-Service Duct Wrap.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; Commercial Board.
      b. Fibrex Insulations Inc.; FBX.
      c. Johns Manville; 800 Series Spin-Glas.
      d. Knauf Insulation; Insulation Board.
      e. Manson Insulation Inc.; AK Board.
      f. Owens Corning; Fiberglas 700 Series.

2.2 ADHESIVES

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

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.
      b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
      b. Vimasco Corporation; 749.
   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
      b. Eagle Bridges - Marathon Industries; 501.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
      d. Mon-Eco Industries, Inc.; 55-10.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
   3. Service Temperature Range: 0 to 180 deg F.
   4. Solids Content: ASTM D 1644, 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
      b. Eagle Bridges - Marathon Industries; 570.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
   3. Service Temperature Range: Minus 50 to plus 220 deg F.
   4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.

b. Vimasco Corporation; 713 and 714.

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

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
c. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
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. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 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, 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.

5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 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..
   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.

2.8 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
      b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
      c. RPR Products, Inc.; Insul-Mate.
   2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ABI, Ideal Tape Division; 428 AWF ASJ.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      c. Compac Corporation; 104 and 105.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ABI, Ideal Tape Division; 491 AWF FSK.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      c. Compac Corporation; 110 and 111.
      d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
   2. Width: 3 inches.
   3. Thickness: 6.5 mils.
   4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-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-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) AGM Industries, Inc.; CHP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches 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.

4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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) GEMCO.
2) Midwest Fasteners, Inc.

2.11 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
   1. Comply with requirements in Section 078413 "Penetration Firestopping" firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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 and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      d. Do not overcompress insulation during installation.
      e. Impale insulation over pins and attach speed washers.
      f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
   4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment.

Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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 and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over compress insulation during installation.

e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the

surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch 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 overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
   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.

3.8 FIELD QUALITY CONTROL

A. 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.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, supply and return.

B. Items Not Insulated:
1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.10 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 thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

D. Concealed, round and flat-oval, exhaust-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

E. Concealed, rectangular, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

F. Concealed, rectangular, return-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

G. Concealed, rectangular, outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

H. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

I. Concealed, return-air plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

J. Concealed, supply-air plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

K. Concealed, outdoor-air plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

L. Concealed, exhaust-air plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

M. Exposed, round and flat-oval, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

N. Exposed, round and flat-oval, return-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

O. Exposed, round and flat-oval, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

P. Exposed, round and flat-oval, exhaust-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

Q. Exposed, rectangular, supply-air duct insulation located in mech. Equipment rooms shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

R. Exposed, rectangular, return-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

S. Exposed, rectangular, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

T. Exposed, rectangular, exhaust-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

U. Exposed, supply-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

V. Exposed, return-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

W. Exposed, outdoor-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

X. Exposed, exhaust-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Rectangular and round, supply-air duct insulation shall be the following:
   1. Expanded Polystyrene: 2 inches
   2. Number of Layers: One.
   3. Vapor Retarder Required: Yes.

C. Rectangular, return-air duct insulation shall be the following:

1. Expanded Polystyrene: 2 inches
2. Number of Layers: One.
3. Vapor Retarder Required: Yes.

3.12 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. Ducts and Plenums:
1. Cover: 8oz. fabric with two coats of weather barrier mastic.
2. Jacket: Aluminum, Corrugated: 0.032 inch thick.

END OF SECTION 230713

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SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:
1. Condensate drain piping, indoors.
2. Chilled-water and brine piping, indoors and outdoors.
3. Heating hot-water piping, indoors and outdoors.
4. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:
1. Section 230713 "Duct Insulation."

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
1. 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 sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 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 "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. 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; Foamglas.
   2. Block Insulation: ASTM C 552, Type I.
   3. Special-Shaped Insulation: ASTM C 552, Type III.
   4. Board Insulation: ASTM C 552, Type IV.
   5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   6. Preformed Pipe Insulation with Factory-Applied **ASJ**: Comply with ASTM C 552, Type II, Class 2.
   7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

H. 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-Degree Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.

e. Owens Corning; Fiberglas Pipe Insulation.

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

I. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

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. Knauf Insulation; Permawick Pipe Insulation.
   b. Owens Corning; VaporWick Pipe Insulation.

J. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Chemical Company (The); Trymer 2000 XP.
   b. Duna USA Inc.; Corafoam.
   c. Dyplast Products; ISO-25.
   d. Elliott Company of Indianapolis; Elfoam.
2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
3. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thickness up to 1 inch as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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. Ramco Insulation, Inc.; Thermokote V.

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

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. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

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.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
      b. Eagle Bridges - Marathon Industries; 290.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
      d. Mon-Eco Industries, Inc.; 22-30.
      e. Vimasco Corporation; 760.
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
   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. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
      b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. 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 LLC; Armaflex 520 Adhesive.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
      d. K-Flex USA; R-373 Contact Adhesive.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
   d. Mon-Eco Industries, Inc.; 22-25.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.
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. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60.

H. 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
   d. Mon-Eco Industries, Inc.; 22-25.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

I. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 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; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
      b. Vimasco Corporation; 749.
   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
      b. Eagle Bridges - Marathon Industries; 501.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
      d. Mon-Eco Industries, Inc.; 55-10.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
   3. Service Temperature Range: 0 to 180 deg F.
   4. Solids Content: ASTM D 1644, 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
      b. Eagle Bridges - Marathon Industries; 570.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
   3. Service Temperature Range: Minus 50 to plus 220 deg F.
   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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
      b. Eagle Bridges - Marathon Industries; 550.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
      d. Mon-Eco Industries, Inc.; 55-50.
      e. Vimasco Corporation; WC-1/WC-5.
   2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 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 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

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..
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 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.

C. Metal Jacket:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
   d. 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- 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 Products, Inc.; 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. ABI, Ideal Tape Division; 428 AWF ASJ.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
   c. Compac Corporation; 104 and 105.

d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. 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. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.
2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. 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 thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the 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 piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
   6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
   7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
   8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations 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 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.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.9 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
   2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of polyisocyanurate insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.11 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
   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. Tests and Inspections:
   1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three 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.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.13 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.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 3/4 inch thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   c. Vapor Barrier: Required

B. Chilled Water and Brine:
1. NPS 3 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I or Pipe Insulation Wicking System: 1-1/2 inches thick.
   b. Vapor Barrier: Required.
2. NPS 4 to NPS 12: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I or Pipe Insulation Wicking System: 2 inches thick.
   b. Vapor Barrier: Required.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
1. NPS 1-1/4 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
2. NPS 1-1/2 and Larger: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

D. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1-1/2 inch thick.
   b. Vapor Barrier: Required.

E. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1-1/2 inch thick.
   b. Vapor Barrier: Required.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:
1. All Pipe Sizes: Insulation shall be the following:
   a. Polyisocyanurate: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 2 inches thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 2 inches thick.

3.16 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

3.17 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. Flanges, Fittings, Valves, and Specialties Concealed:
   1. PVC: 20 mils thick.

C. Piping, Flanges, Fittings, Valves, and Specialties Exposed:
   1. PVC: 20 mils thick.

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed:
   1. Aluminum, Corrugated: 0.032 inch thick.

C. Piping, Exposed:
   1. Aluminum, Corrugated: 0.032 inch thick.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

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 commissioning process requirements for the following HVAC&R systems, assemblies, and equipment:
   1. Cooling generation systems, including chilled-water systems and direct-expansion systems.
   2. Distribution systems, including air distribution (heating and cooling) systems, glycol distribution systems, chilled-water distribution systems, air-handling units.
   3. Terminal and packaged units, including unit ventilators finned-tube radiation, packaged units.
   4. Vibration and sound systems, including sound attenuation, and vibration isolation devices.
   5. Controls and instrumentation, including BAS.
   6. Systems testing and balancing verification, including chilled-water piping systems supply-air systems, return-air systems, exhaust-air systems.

B. Related Requirements:

   1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements and Commissioning Coordinator responsibilities.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. DDC: Direct digital controls.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

E. TAB: Testing, adjusting, and balancing.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For BAS and Testing Technician.

B. Construction Checklists: See related Sections for technical requirements for the following construction checklists:

1. Vibration and seismic controls for HVAC&R piping and equipment.
2. Instrumentation and control for HVAC&R.
3. Cooling-water piping and accessories.
4. Refrigerant piping.
5. Metal ducts and accessories.
6. Fans.
7. Particulate air filtration.
8. Air-handling units.
9. Chillers.
10. Pumps.

1.5 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level with knowledge of BAS, HVAC&R, electrical concepts, and building operations.
2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
3. International Society of Automation (ISA) Certified Control Systems Technician (CCST) Level I.

B. HVAC&R Testing Technician Qualifications: Technicians to perform HVAC&R construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level. Vocational School four-year program graduate or an Associates degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC&R systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC&R equipment, assemblies, and systems.
2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
3. One of the following:

    a. National Environmental Balancing Bureau (NEBB) Certified Testing, Adjusting, and Balancing Technician.
    b. Associated Air Balance Council (AABC) Certified Test and Balance Technician.
    c. Owner retains the right to waive NEBB or AABC Certification.

C. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform HVAC&R commissioning work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:

   a. Equipment/instrument identification number.
   b. Planned commissioning application or use.
   c. Manufacturer, make, model, and serial number.
   d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.

2. Test equipment and instrumentation shall meet the following criteria:

   a. Capable of testing and measuring performance within the specified acceptance criteria.
   b. Be calibrated at the manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
   c. Be maintained in good repair and operating condition throughout the duration of use on this Project.
   d. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the commissioning process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:

   a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:

      1) Instrument or tool identification number.
      2) Equipment schedule designation of equipment for which the instrument or tool is required.
      3) Manufacturer, make, model, and serial number.
      4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

   b. Include a separate list of proprietary test instrumentation and tools in the operation and maintenance manuals.
   c. HVAC&R proprietary test instrumentation and tools become the property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.

F. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.

G. Construction Checklists: Prepare and submit detailed construction checklists for HVAC&R systems, subsystems, equipment, and components.

1. Contributors to the development of construction checklists shall include, but are not limited to, the following:

    a. HVAC&R systems and equipment installers.
    b. TAB technicians.
    c. HVAC&R instrumentation and controls installers.

H. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by Commissioning Coordinator and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Commissioning test procedures may direct that set points be altered when simulating conditions is impractical.

3. Commissioning test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.

J. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

K. Coordinate schedule with, and perform the following activities at the direction of, Commissioning Coordinator.

L. Comply with construction checklist requirements, including material verification, installation checks, start-up, and performance tests requirements specified in Sections specifying HVAC systems and equipment.

M. Provide technicians, instrumentation, tools, and equipment to complete and document the following:

1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Commissioning tests.
4. Commissioning test demonstrations.

3.2 TAB COMMISSIONING TESTS

A. TAB Verification:

1. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
3. Scope: HVAC&R air systems and hydronic piping systems.
4. Purpose: Differential flow relationships intended to maintain air pressurization differentials between the various areas of Project.
5. Conditions of the Test:

    a. Commissioning Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
    b. Systems operating in full heating mode with minimum outside-air volume.
    c. Systems operating in full cooling mode with minimum outside-air volume.
    d. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

6. Acceptance Criteria:

a. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
b. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.
c. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.3 CENTRAL REFRIGERATION SYSTEM COMMISSIONING TESTS

A. Start and Stop Chilled-Water Pump(s):

1. Prerequisites: Installation verification of the following:

a. Startup of chilled-water pump(s).
b. Input Device: Flow switch in condenser-water circuit.
c. Output Device: DDC system command to starter relay.
d. Display of the following at the operator's workstation:

1) Chilled-water flow indication.
2) Chilled-water pump(s) on-off status.
3) Chilled-water pump(s) on-off indication.

2. Scope: Chilled-water system, including chilled-water pump(s), associated controls, and condenser-water system controls.
3. Purpose:

a. Chilled-water pump(s) start.
b. Chilled-water pump(s) shutdown.

4. Conditions of the Test:

a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device to the "disable" state.

5. Acceptance Criteria:

a. Start: Chilled-water pump(s) start when and only when the enable-input device is in the "enable" state.
b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

B. Chiller(s):

1. Prerequisites: Installation verification of the following:

a. Input Device: DDC system software.
b. Output Device: Chiller terminal strip.

c. Display:

1) Chiller(s) on-off indication.
2) Chiller failure alarm.

2. Scope:

a. Chilled-water system and associated controls.
b. Condenser-water system and associated controls.

3. Purpose:

a. Lead-lag rotation of chillers.
b. Replacement of failed chiller in rotation.
c. Replacement of failed chiller in add/drop sequence.
d. Chiller failure alarm initiation.

3.4 AIR-HANDLING SYSTEM COMMISSIONING TESTS

A. Air-Handler Mixed-Air Control:

1. Prerequisites: Installation verification of the following:

a. Minimum Position Input Device: DDC system time schedule.
b. Output Device: Receiver controller to modulating damper actuator(s).
c. Heating Reset Input Device: Room thermostat.
d. Supply or mixed -Air Temperature Input Device: Duct-mounted thermostat Electronic temperature sensor.
e. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted thermostats or electronic temperature sensors.
f. Display the following at the operator's workstation:

1) Mixed-air-temperature indication.
2) Mixed-air-temperature set point.
3) Mixed-air damper position.

2. Scope: Air handler with mixed-air control and associated controls.
3. Purpose:

a. Occupied time control.
b. Minimum damper position control.
c. Heating reset control.
d. Supply or Mixed -air temperature control.
e. Cooling reset control.
f. Unoccupied time control.

4. Conditions of the Test:

a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.

b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
c. Heating Reset Control: Create a call for heating.
d. Supply or Mixed - Air Temperature Control: Override supply or mixed-air temperature set point to a value 2.0 deg F (1.1 deg C) above current supply or mixed-air temperature.
e. Cooling Reset Control: Override outdoor-air temperature to a value that exceeds return-air temperature.
f. Unoccupied Time Control: Advance to unoccupied schedule time.
g. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at hourly intervals. Submit trend data for 24-hour periods in which natural conditions require heating reset control, supply or mixed-air temperature control, and cooling reset control.

    1) Minimum position input device.
    2) Heating reset input device.
    3) Supply or Mixed - air temperature input device.
    4) Cooling reset input device.

5. Acceptance Criteria:

    a. Occupied Time Control: Mixed-air control is active in occupied mode.
    b. Minimum Damper Position Control: Controller opens minimum outdoor-air dampers.
    c. Heating Reset Control: Controller sets outdoor-air dampers to minimum position.
    d. Supply or Mixed -Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary supply mixed -air temperature set point plus or minus 1.0 deg F (0.6 deg C) .
    e. Cooling Reset Control: Controller sets outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature.
    f. Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
    g. Control Data Trend Log: Data verifies control according to sequence of control.

END OF SECTION 230800

SECTION 230900 - 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. Controls shall be compatible with the Johnson Facility Explorer Hardware/Software.

B. Controls shall be integrated into the existing controls system.

C. 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.

D. Related Sections include the following:
   1. Section 230519 "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
   2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.4 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. 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 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.

1.5 PROJECT RECORD DOCUMENTS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Maintenance instructions and lists of spare parts for each type of control device.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   4. Calibration records and list of set points.

1.6 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.

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.

1.7 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 to latest version of software at Project completion.

1.8 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment and installation with Sections 26, 27, and 28, as appropriate, for systems integration requirements.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Section 262416 "Panelboards" to achieve compatibility with starter coils and annunciation devices.

E. Coordinate equipment with Section 262419 "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

F. All external wiring of equipment, all temperature control wiring, external wiring of control circuits of magnetic starters, interlocking wiring, boiler wiring, Emergency Break Glass Stations, and mounting of control devices, etc., shall be included under Division 23. All external wiring shall be in conduit. Provide 120V power to all necessary control panels, controllers, etc. from nearest spare panelboard circuit breaker location. Furnish and install necessary circuit breakers. If facility contains emergency power, connect circuit(s) to emergency panelboards.

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. Compatible with Johnson Facility Explorer.
   3. Compatible with the existing controls system, field verify and coordinate with owner.

B. Service Requirements: The manufacturer’s service representative must be located within 50 miles of the project site, and have a maximum service call response time of 24 hours. The service representative must have a minimum of 5 years experience maintaining the control system manufacturer’s equipment.

2.2 CONTROL SYSTEM

A. Manufacturers:
   1. Johnson Controls, Inc.; Controls Group., All Controls shall be compatible with the Johnson facility explorer system that is being installed in an upcoming energy performance contract and existing facility controls.

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. 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 condenser-water reset, 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.
   5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

B. 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.
4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will not cause 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.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
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.

D. 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.

E. 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. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

4. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

2.5 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

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, 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.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
   1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.
   2. Proportional band shall extend from 2 to 20 percent for 5 psig.
   3. Authority shall be 20 to 200 percent.
   4. Air-supply pressure of 18 psig, input signal of 3 to 15 psig, and output signal of zero to supply pressure.
   5. Gages: 2-1/2 inches in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

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. Manufacturers:
      a. BEC Controls Corporation.
      b. Ebtron, Inc.
      c. Heat-Timer Corporation.
      d. I.T.M. Instruments Inc.
      e. MAMAC Systems, Inc.
      f. RDF Corporation.
   2. Accuracy: Plus or minus 0.5 deg F at calibration point.
   3. Wire: Twisted, shielded-pair cable.
   4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
   5. Averaging Elements in Ducts: 60 inches in length per 10 sq. ft. of duct cross-sectional area; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
   6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
   7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
      b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
   8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:
   1. Manufacturers:
      a. BEC Controls Corporation.
      b. MAMAC Systems, Inc.
      c. RDF Corporation.
   2. Accuracy: Plus or minus 0.2 percent at calibration point.
   3. Wire: Twisted, shielded-pair cable.
   4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
   5. Averaging Elements in Ducts: 60 inches in length per 10 sq. ft. of duct cross-sectional area; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.; length as required.
   6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
   7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
      b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
   8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

D. Humidity Sensors: Bulk polymer sensor element.
   1. Manufacturers:
      a. BEC Controls Corporation.
      b. General Eastern Instruments.
      c. MAMAC Systems, Inc.
      d. ROTRONIC Instrument Corp.
      e. TCS/Basys Controls.
      f. Vaisala.
   2. Accuracy: 2 percent full range with linear output.
   3. Room Sensor Range: 20 to 80 percent relative humidity.

4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
   b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 20 to plus 170 deg F.
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:
1. Manufacturers:
   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. TCS/Basys Controls.
   f. Vaisala.
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- to 0.25-inch wg.
   d. Duct Static-Pressure Range: 0- to 5-inch wg.
3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. 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.
   a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
   b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.

G. Room sensor accessories include the following:
1. Insulating Bases: For sensors located on exterior walls.
2. Adjusting Key: As required for calibration and cover screws.

2.8 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. 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.

C. 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.

D. 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.

E. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

F. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

G. 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. Manufacturers:
      a. BEC Controls Corporation.
      b. I.T.M. Instruments Inc.

2.9 THERMOSTATS

A. Manufacturers:
   1. Erie Controls.
   2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
   3. Heat-Timer Corporation.
   4. Sauter Controls Corporation.
   5. tekmar Control Systems, Inc.
   6. Theben AG - Lumilite Control Technology, Inc.

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", "FAN HIGH-MED-LOW-OFF", or as required based on the requirements.
   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 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 set-point range, and 2 deg F 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 set-point range, and 2 deg F maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

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. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

H. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

I. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

J. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.
1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. 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, and cast housing with position indicator and adjusting knob.

2.10 HUMIDISTATS

A. Manufacturers:
1. MAMAC Systems, Inc.
2. ROTRONIC Instrument Corp.

B. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.11 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 Section 230513 "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: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
   4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
   5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
   6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
   7. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb. torque capacity shall have a manual crank.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   1. Manufacturers:
      a. Belimo Aircontrols (USA), Inc.
   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. of damper.
      b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
      c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
      d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
      e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
      f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: 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. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb. torque capacity shall have a manual crank.
   8. Power Requirements (Two-Position Spring Return): 24-V ac.
   9. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

10. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
11. Temperature Rating: 40 to 104 deg F, unless used for outdoor applications.
12. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
13. Run Time: 12 seconds open, 5 seconds closed.

2.12 CONTROL VALVES

A. Manufacturers:
1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
2. Erie Controls.
3. Hayward Industrial Products, Inc.
4. Magnatrol Valve Corporation.
5. Neles-Jamesbury.
6. Parker Hannifin Corporation; Skinner Valve Division.
7. Pneuline Controls.
8. Sauter Controls Corporation.

B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Hydronic system globe valves shall have the following characteristics:
1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
   a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
   b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:
   a. Two Position: Line size.
   b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
   c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
1. Body Style: Lug or Grooved.
2. Disc Type: Aluminum bronze.
3. Sizing: 1-psig maximum pressure drop at design flow rate.

E. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
   1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
   2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
   3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

F. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
   1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
   2. Thermostatic Operator: Liquid-filled remote sensor with integral adjustable dial.

2.13 DAMPERS

A. Manufacturers:
   1. Air Balance Inc.
   2. Don Park Inc.; Autodamp Div.
   3. TAMCO (T. A. Morrison & Co. Inc.).
   4. United Enertech Corp.
   5. Vent Products Company, Inc.

B. Dampers: AMCA-rated, parallel and opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches. Blades shall be airfoil type suitable for wide-open face velocity of 2000 fpm.
   1. Provide parallel blade design for two-position applications.
   2. Provide opposed-blade design for modulating applications.
   3. Secure blades to 1/2-inch- 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.
   4. Operating Temperature Range: From minus 40 to plus 200 deg F.
   5. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
   6. Edge Seals, 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. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.
   7. Sections: Damper sections shall not exceed 48 in. x 60 in. Each section shall have at least one damper actuator.
   8. Linkages: Dampers shall have exposed linkages.

2.14 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 INSTALLATION

A. Install software in control units and operator workstation. 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. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install wall-mounted devices 60 inches above the floor.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:
   1. Entrances.
   2. Public areas.
   3. Where indicated.

E. Install automatic dampers according to Section 233300 "Air Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."

H. Install hydronic instrument wells, valves, and other accessories according to Section 232116 Hydronic Piping Specialties."

I. Install steam and condensate instrument wells, valves, and other accessories according to Section 232216 Steam and Condensate Piping Specialties."

J. Install refrigerant instrument wells, valves, and other accessories according to Section 232300 "Refrigerant Piping."

K. Install duct volume-control dampers according to Section 233113 "Metal Ducts".

L. Install electronic and fiber-optic cables according to Section 271500 "Communications Horizontal Cabling."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."

B. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Section 271500 "Communications Horizontal Cabling."
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.

4. Bundle and harness 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.

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.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
7. Test each system for compliance with sequence of operation.
8. Test software and hardware interlocks.

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 flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
7. Check temperature instruments and material and length of sensing elements.
8. Check control valves. Verify that they are in correct direction.
9. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
10. 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: 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 three visits to Project during other than normal occupancy hours for this purpose.

3.6 TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be provided via classroom and on-site training. Training shall be tailored to Owner’s requirements.

B. Provide Owner training for the equivalent of 4 hours each for 3 persons.

C. Training shall enable students to accomplish the following objectives.
1. Proficiently operate system
2. Understand control system architecture and configuration
3. Understand DDC system components
4. Understand system operation, including DDC system control and optimizing routines (algorithms)
5. Adjust and change system setpoints, time schedules, and holiday schedules
6. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
7. Understand system drawings and Operation and Maintenance manual
8. Understand job layout and location of control components
9. Access data from DDC controllers
10. Create, delete, and modify alarms, including configuring alarm reactions
11. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
12. Configure and run reports
13. Add, remove, and modify system's physical points
14. Create, modify, and delete application programming
15. Add operator interface stations
16. Add a new controller to system
17. Download firmware and advanced applications programming to a controller
18. Configure and calibrate I/O points
19. Maintain software and prepare backups
20. Interface with job-specific, third-party operator software
21. Add new users and understand password security procedures

D. Instructors shall be factory-trained and experienced in presenting this material.

E. Perform classroom training using a network of working controllers representative of installed hardware.

END OF SECTION 230900

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SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems and equipment.

1.2 DEFINITIONS

A. BMS: Building Management System.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 HVAC CONTROL SEQUENCES

A. All components shall be compatible with the existing Johnson Facility Explorer controls system.

B. All set points shall be adjustable.

C. Coordinate with Owner on required system alarms.

D. Obtain building occupancy schedules from Owner.

E. General
1. All set points, changeover points and reset schedules shall be user adjustable.
2. Control algorithms shall utilize tuned PID loops to maintain set points and minimum/maximum leaving air temperatures optimally.
3. Coordinate individual alarm notifications with Owner.
4. Alarms shall be configured as status only or critical. Status only alarms shall display alarm on the Owner coordinated workstation(s) and device(s). Critical alarms shall incorporate coordinated unit shutdown along with displaying alarms on the Owner coordinated devices and require the alarm to be cleared prior to restarting the equipment.
5. All HVAC equipment shall operate in occupied/unoccupied modes as determined by the DDC building time clock system. Obtain the building occupancy schedule from the Owner.
6. All equipment shall utilize optimum start/stop programs.
7. Assign all equipment a stagger start number to keep to many units from starting at the same time. In effect, this flattens load peaks. This includes start-up on emergency power.
8. Unoccupied override buttons shall place the space equipment in occupied mode for a period of one-hour (adjustable).
9. Coordinate chilled water valve and chilled water pump response time with the chiller manufacturer's maximum rate of change in chilled water flow.

F. Universal Set Points. Unless otherwise noted, use the following space temperature set points. Set points shall be independently adjustable by space through the BMS.

	Occupied Modes		Unoccupied Modes	
	Cooling	Heating	Cooling	Heating
Occupied Spaces	74°F	69°F	85°F	55°F

Unoccupied Spaces	80°F	60°F	85°F	55°F

G. Hydronic Fan Coil Unit
1. Assign each fan coil unit a stagger start number to keep too many units from starting at the same time. In effect, this flattens load peaks.
2. Warm-Up Mode Control:
   a. Optimum start duration shall be determined based on outside air temperature.
   b. During the optimum start period, the heating set-point will be linearly ramped up from unoccupied heating set-point to occupied heating set-point.
   c. When the heating set-point crosses above the space temperature, the supply fan will be commanded on, the mixing dampers shall remain in the full return air position and the heating valve will modulate to maintain heating set-point.
3. Cool-Down Mode Control:
   a. Optimum start duration shall be determined based on outside air temperature.
   b. During the optimum start period, the cooling set-point will be linearly ramped down from unoccupied cooling set-point to occupied cooling set-point.
   c. When the cooling set-point crosses below the space temperature, the supply fan will be commanded on, the mixing dampers shall modulate to the full return air position and the chilled water control valve shall modulate to maintain the space cooling set-point.
4. Occupied Mode:
   a. Supply Fan:
      1) Enable continuously.
   b. Mixed Air Damper:
      1) Open to maintain outside air quantity as scheduled, outside air damper shall never be positioned below this minimum except in case of emergency.
   c. Occupied Heating Mode (OAT is above 55°F and space temperature below set point)
      1) Modulate HHW coil control valve to maintain space temperature set point and minimum discharge air set point.
         a) Minimum leaving air temperature reset schedule:
            65 degree LAT at 0 degree OAT.
            55 degree LAT at 55 degree OAT.
      2) Modulate the CHW coil control valve to the full closed position.
   d. Occupied Cooling Mode (OAT is above 60°F and space temperature is above set point)
      1) Modulate the HHW coil control valve to the full closed position.
      2) Modulate the CHW coil control valve to maintain the space temperature setpoint.
5. Unoccupied Mode:
   a. Supply Fan:
      Start (2°F below heating set point) and stop (1°F above heating set point) to maintain space temperature set point.
   b. Mixed Air Damper:
      Fully return air position.
   c. Hot Water Coil Control Valve:
      Same as occupied mode.
   d. Chilled Water Control Valve

- Modulate to full closed position unless night cooling is required. When night cooling is required, modulate valve to maintain space temperature set point.

6. Alarms – Provide an alarm for each of the following:
   a. Fan fails to run after 30 seconds of being commanded on.
   b. Fan fails to stop after 30 seconds of being commanded off.
   c. Software safety trip.
   d. Software safety lockout (4 safety trips in 3 hours).
   e. Low or high discharge air temperatures.
   f. Low or high space temps.

H. **AHU-1,2,3,4**
1. All Occupied Modes:
   a. Unit Supply Fan:
      1) Run continuously.
   b. Unit Exhaust Fan:
      1) Run continuously.
   c. See section 3.2 for demand control ventilation.
2. Occupied Heating Mode –space temperature below set point.
   a. Heating coil: Modulate hot water coil control valve (CV) to maintain space temperature set point.
   b. Space Temperature Set Points:
      1) Heating = 69 degrees (adjustable).
   c. LAT Temperature Set Points:
      Minimum temperature reset schedule:
      65 degree LAT at 0 degree OAT.
      55 degree LAT at 55 degree OAT.
   d. Heat exchanger face and bypass damper: Modulate damper as recommended by the unit manufacturer for the heat exchanger defrost cycle.
3. Occupied Cooling Mode – space temperature below set point. – where applicable
   a. Unit mounted cooling coil: Modulate control valve to maintain space temperature set point.
   b. Space Temperature Set Points:
      1) Cooling = 75 degrees (adjustable).
   c. LAT Temperature Set Points:
      1) Cooling = 55 degree LAT at 88 degree OAT
4. Occupied Economizer Cooling Mode – when there is call for cooling and the outdoor air temperature is below the space temperature.
   a. Economizer cooling set point: 74°F.
   b. Fully open recirculation damper.
   c. If the space temperature rises above the cooling setpoint of 75 degrees F (adjustable), and the controls indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the DX cooling stages will be energized.
   d. Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. DX cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.
   e. The controls will monitor fan status and generate an alarm whenever the fan is commanded on but the status indicates off. Alarms will also be generated if a freeze condition exists or if a low space temperature is detected.

5. All Unoccupied Modes:
   a. Space Temperature Set Points:
      1) Heating = 60 degrees.
      2) Cooling = 85 degrees.
      3) There shall be a 5 degree deadband for heating and cooling set points.
   b. Heating Coil:
      1) All same as occupied mode with following exceptions:
         a) Enable and disable unit only to meet temperature set point.
         b) Disable exhaust fan.
         c) Open recirculation damper.
   c. Purge Mode Control:
      1) Purge mode (fresh air changeover) shall only be permitted during an unoccupied period.
      2) If the outside air is between 45°F and 65°F and the average space temperature rises above 75°F, the supply fan shall be commanded on, the outdoor air dampers shall be fully open, the heating valve and dx cooling coil control shall be fully closed, the return fan shall be enabled at the maximum scheduled airflow and the recirculation dampers shall be fully open. When the space temperature drops to 70°F, the fans shall be commanded off and the dampers shall return to the normal unoccupied mode position.
6. Warm-up Mode.:
   a. All units shall start per optimum start program.
      1) Optimum start duration shall be determined based on outside air temperature.
      2) During the optimum start period, the heating set-point shall be linearly ramped up from unoccupied heating set-point to occupied heating set point.
   b. Systems shall operate as described in unoccupied heating mode with temperature set point equal to occupied mode.
7. Alarms – Provide an alarm for each of the following:
   a. Fan motor failures.
   b. Discharge Air Temperature low/high limits.
   c. Freeze condition.
   d. Drain pan.
   e. Space Temperature low/high limits +/-5°F.
   f. VFD Fault.

I. AHU-5 & RTU-4
1. Hood Exhaust Flows:
   a. PRV-5 Dishwasher Hood EA = 1400 cfm
   b. PRV-7 Kitchen hood EA = 4810 cfm
   c. PRV-8 Server hood EA = 2000 cfm
2. Air Balance:

Air Balance			
	Occupied Hoods Off		
	OA	EA	Press.
AHU-5	500	-2000	(e) GI
RTU-4	6600	-4500	EF-4
	7100	-6500	600
	Occupied all Hoods On		
	OA	EA	Press.
AHU-5	500	-1400	-900
RTU-4	6600	-7910	-1310
	7100	-9310	-2210

3. All Occupied Modes:
   a. In addition to scheduled occupied modes, when existing powered vent fans PRV-5, 7&8 are enabled, AHU-5 & RTU-4 shall be indexed to occupied mode.
   b. Supply Fan:
      1) Run continuously at balanced airflow.
   c. Exhaust Fan:
      1) Existing range hood exhaust fans PRV-5,7&8 shall operate all together at the same time.
      2) Unit exhaust fans shall operate continuously were applicable.
   d. Outside Air Damper:
      1) Open to maintain scheduled standard minimum outside air quantity measured by the airflow measuring station. The outside air damper shall never be positioned below this minimum except in case of emergency.
      2) Modulate outside air damper beyond scheduled minimum as required for
         a) Economizer cooling. See cooling mode below.
         b) When existing EF is enabled, open outdoor air damper to 100% open position and open supply air energy recovery wheel bypass damper.
   e. Return air damper
      1) Modulate inversely with outdoor air damper.
   f. Occupied Heating Mode (OAT is above 55°F and space temperature below set point)
      1) Modulate HHW coil control valve to maintain space temperature set point.
      2) Enable energy recovery wheel when exhaust fan is enabled. Close bypass dampers.
      3) If exhaust air temperature after the ERW is 35°F(adjustable) or below, open exhaust air bypass damper to allow defrost of wheel for a period of 10-minutes(adjustable).
      4) Modulate the CHW coil control valve to the full closed position.
   g. Occupied Cooling Mode (OAT is above 60°F and space temperature is above set point)
      1) Unless in economizer mode or when exhaust fan is disabled, enable energy recovery wheel. Close bypass dampers.
      2) Modulate the HHW coil control valve to the full closed position.

3) Occupied Economizer Cooling Mode – when there is call for cooling, the outdoor air enthalpy is below the return air enthalpy and the exhaust fan is enabled.
   a) Modulate outdoor air damper inversely with exhaust fan to maintain space temperature set point.
   b) Disable energy recovery wheel.
   c) Fully open energy recovery wheel bypass dampers.
   d) Modulate chilled water control valve open only after the economizer is at its full open position.

4. All Unoccupied Modes:
   a. All same as occupied mode with following exceptions:
      1) Enable and disable unit only to meet temperature set points or as described in purge mode control.
      2) Return air damper shall be in the full open position unless in purge mode.
      3) Exhaust fan shall remain disabled except as described in purge mode control.
      4) The outdoor air damper shall remain closed except as described in purge mode control.
   b. Purge Mode Control:
      1) Purge mode (fresh air changeover) shall only be permitted during an unoccupied period.
      2) If the outside air is between 45°F and 65°F and the space temperature rises above 75°F, the supply fan shall be commanded on, the outdoor air dampers shall be fully open, the heating and cooling coil control valves shall be fully closed, the integral relief fan shall be enabled at the maximum scheduled airflow and the ERW bypass dampers shall be fully open. When the space temperature drops to 70°F, the fans shall be commanded off and the dampers shall return to the normal unoccupied mode position.
5. Warm-up and Cool Down Modes:
   a. All units shall start per optimum start program.
      1) Optimum start duration shall be determined based on outside air temperature.
      2) During the optimum start period, the space temperature set point shall be linearly ramped from the unoccupied set-point to the occupied set point.
      3) When the space temperature crosses the occupied mode set point, the supply fan shall be commanded on, the mixing dampers shall remain closed and the HHW or CHW valve shall modulate to maintain the space temperature set-point.
   b. Systems shall operate as described in unoccupied modes with temperature set point equal to occupied mode.
6. Alarms – Provide an alarm for each of the following:
   a. Fan motor failures.
   b. Discharge Air Temperature low/high limits.
   c. Space Temperature low/high limits +/-5°F.
   d. High filter static
   e. Low coil entering air temperature
   f. High water level in drain pan
   g. VFD fault

J. RTU-1,2,3

1. All Occupied Modes:
   a. Unit Supply Fan:
      1) Run continuously.
   b. Unit Exhaust Fan:
      1) Run continuously.
2. Occupied Heating Mode –space temperature below set point.
   a. Heating coil: Modulate heating coil control valve (CV) to maintain space temperature set point.
   b. Space Temperature Set Points:
      1) Heating = 69 degrees (adjustable).
   c. LAT Temperature Set Points:
      Minimum temperature reset schedule:
      65 degree LAT at 0 degree OAT.
      55 degree LAT at 55 degree OAT.
   d. Heat exchanger face and bypass damper: Modulate damper as recommended by the unit manufacturer for the heat exchanger defrost cycle.
3. Occupied Cooling Mode – space temperature below set point. – where applicable
   a. Unit mounted DX cooling coil: Modulate DX compressor to maintain space temperature set point.
   b. Space Temperature Set Points:
      1) Cooling = 75 degrees (adjustable).
   c. LAT Temperature Set Points:
      1) Cooling = 55 degree LAT at 88 degree OAT
4. Occupied Economizer Cooling Mode – when there is call for cooling and the outdoor air temperature is below the space temperature.
   f. Economizer cooling set point: 74°F.
   g. Fully open recirculation damper.
   h. If the space temperature rises above the cooling setpoint of 75 degrees F (adjustable), and the controls indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the DX cooling stages will be energized.
   i. Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. DX cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.
   j. The controls will monitor fan status and generate an alarm whenever the fan is commanded on but the status indicates off. Alarms will also be generated if a freeze condition exists or if a low space temperature is detected.
5. All Unoccupied Modes:
   a. Space Temperature Set Points:
      1) Heating = 60 degrees.
      2) Cooling = 85 degrees.
      3) There shall be a 5 degree deadband for heating and cooling set points.
   b. Heating Coil:
      1) All same as occupied mode with following exceptions:
         a) Enable and disable unit only to meet temperature set point.
         b) Disable exhaust fan.
         c) Open recirculation damper.
6. Warm-up Mode.:
   a. All units shall start per optimum start program.

1) Optimum start duration shall be determined based on outside air temperature.
2) During the optimum start period, the heating set-point shall be linearly ramped up from unoccupied heating set-point to occupied heating set point.

b. Systems shall operate as described in unoccupied heating mode with temperature set point equal to occupied mode.

7. Alarms – Provide an alarm for each of the following:
   a. Fan motor failures.
   b. Discharge Air Temperature low/high limits.
   c. Freeze condition.
   d. Drain pan.
   e. Space Temperature low/high limits +/-5°F.
   f. VFD Fault.

K. Relief Fans

1. Occupied Mode
   a. Enable fan at all times.
   b. Enable fan at minimum scheduled airflow unless any of the associated unit ventilators are in economizer mode.
      1) When the associated UV's are in economizer mode, modulate fan beyond its minimum scheduled airflow based on the average outdoor air damper position of the associated unit ventilators.
2. Unoccupied Mode (including unoccupied as sensed by occupancy sensor during scheduled occupied mode.)
   a. Disable fan at all times except as outlined in the unit ventilator Purge Mode.
3. Alarms
   a. Fan fails to run after 30 seconds of being commanded on.
   b. Fan fails to stop after 30 seconds of being commanded off.

L. Exhaust Fans

a. Occupied mode: Open damper and enable fan after 15-second delay.
b. Unoccupied mode: Disable fan and modulate damper to full closed position after 15-second delay.

2. Alarms
   a. Fan fails to run after 30 seconds of being commanded on.
   b. Fan fails to stop after 30 seconds of being commanded off.

M. VRF system air conditioners:

1. Unoccupied and occupied modes: Modulate compressors as necessary to maintain space temperature set point of 75°F (adjustable).
2. Alarms.
   a. Equipment failure.
   b. Temperature high/low limits.

N. Unit Ventilators With cooling

1. Associated equipment is fin-tube radiation where indicated on plans.
2. Unit ventilator shall operate in occupied/unoccupied modes as determined by the DDC building time clock system and by occupancy sensor.
3. Assign each unit ventilator a stagger start number to keep too many units from starting at the same time. In effect, this flattens load peaks.

4. Occupied heating set-point, unoccupied heating set-point, unoccupied cooling set-point and purge enable/disable shall be global and fully adjustable from any interface.
5. Outside air is admitted to meet ventilation and cooling requirements as outlined in the individual unit sequences. Mechanical cooling, if equipped is utilized as outlined in the individual unit sequences.
6. Each unit ventilator shall have a software HOA for control of the supply fan.
7. Wire the supply fan normally open at the control relay and fail off.
8. Control cycle to follow ASHRAE Cycle II Standard.
9. Occupied Economizer Cooling Mode – when there is call for cooling and the outdoor air temperature is below the space temperature.
    a. Economizer cooling set point: 74°F.
    b. Fully open recirculation damper.
    c. If the space temperature rises above the cooling setpoint of 75 degrees F (adjustable), and the controls indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the cooling control valve will modulate.
    d. Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. Cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.
    e. The controls will monitor fan status and generate an alarm whenever the fan is commanded on but the status indicates off. Alarms will also be generated if a freeze condition exists or if a low space temperature is detected.
10. Purge Mode Control:
    a. Purge mode (fresh air changeover) shall only be permitted during an unoccupied period.
    b. If the outside air is between 45°F and 60°F and the space temperature rises above 75°F, the supply fan shall be commanded on, the mixing dampers shall be fully open, the heating coil shall be fully closed and the integral relief fan or associated exhaust fan shall be enabled at the maximum airflow. When the space temperature drops to 70°F, the fans shall be commanded off and the mixing dampers shall return to the normal position.
11. Warm-Up Mode Control:
    a. Optimum start duration shall be determined based on outside air temperature.
    b. During the optimum start period, the heating set-point will be linearly ramped up from unoccupied heating set-point to occupied heating set-point.
    c. When the heating set-point crosses above the space temperature, the supply fan will be commanded on, the mixing dampers shall remain closed and the heating valve will modulate to maintain heating set-point.
12. Cool-Down Mode Control:
    a. Optimum start duration shall be determined based on outside air temperature.
    b. During the optimum start period, the cooling set-point will be linearly ramped down from unoccupied cooling set-point to occupied cooling set-point.
    c. When the cooling set-point crosses below the space temperature, the supply fan will be commanded on, the mixing dampers shall modulate to maintain cooling set-point.
13. Occupied Mode:
    a. Unit Ventilator:
        1) Supply Fan:
            a) Enable continuously.
        2) Outside Air Damper:

a) Open to maintain outside air quantity as scheduled, outside air damper shall never be positioned below this minimum except in case of emergency.
b) Modulate outside air damper beyond scheduled minimum position as follows:
Maintain ventilation cooling temperature set point.

3) Hot Water Coil Control Valve:
a) LAT schedule
Utilize discharge air minimum temperature reset schedule as outlined below.
55°F LAT at 55°F OAT
65°F LAT at 0°F OAT.
Utilize discharge air temperature PID loop to maintain space temperature set point and minimum LAT.
b) Outside air temperature drops below 35 degrees:
Modulate full open. (Valve shall stay full open until O.A. rises above 38 degrees).
c) Outside air temperature above 38 degrees:
Modulate to maintain space temperature set point. Modulate to maintain 65 degree minimum discharge air temperature during heating mode.

4) Coil Face and By-pass Damper :
a) Outside air temperature drops below 35 degrees:
Modulate to maintain space temperature set point. Modulate to maintain 65 degree minimum discharge air temperature.
Modulate until O.A. rises above 38 degrees.
b) Outside air temperature above 38 degrees:
Position to full coil face position.

5) RA Damper:
a) Modulate with outside air damper to maintain the following balance: RA CFM = SA CFM – OA CFM.

6) Cooling Coil (as indicated on the drawings):
a) Modulate valve to maintain space temperature set point.

14. Unoccupied Mode By Occupancy Sensor during DDC scheduled occupied period
a. During the scheduled occupied mode, when the space is unoccupied as sensed by the room occupancy sensor, the damper will be closed to outside air.
b. In heating mode, the space temperature set-point shall be reset to 2°F (adjustable) lower than the occupied set-point. In cooling mode, the space temperature set-point shall be reset to 2°F (adjustable) higher than the occupied set-point.
c. The supply fan shall cycle on and off to maintain the space temperature set-point. In heating mode, the finned-tube control valve shall continue to modulate to maintain the space temperature set point. If the space temperature drops 1°F below in the reset heating set-point, the supply fan shall be commanded on, the mixing damper shall remain closed and the heating valve shall modulate open. When the space temperature rises 1°F above the reset heating set-point, the supply fan shall be commanded off. In cooling mode, if the space temperature rises 1°F above in the reset cooling set-point, the supply fan shall be commanded on, the mixing damper shall remain closed and the cooling valve shall modulate open. When the space temperature drops 1°F below the reset cooling set-point, the supply fan shall be commanded off.

d. When the space is occupied as sensed by the room occupancy sensor, the sequence shall be indexed to the occupied mode.

15. Unoccupied Mode By DDC Schedule:
    a. Unit Ventilators
        1) Supply Fan:
            Start (2°F below heating set point) and stop (1°F above heating set point) to maintain space temperature set point.
        2) Outside Air Damper:
            Fully closed.
        3) Hot Water Coil Control Valve:
            Same as occupied mode.
        4) Coil Face and By-pass Damper:
            Same as occupied mode.
        5) RA Damper:
            Fully open.
        6) Cooling Water Coil Control Valve:
            - Modulate to full closed position unless night cooling is required. When night cooling is required, modulate valve to maintain space temperature set point.
16. Alarms – Provide an alarm for each of the following:
    a. Fan fails to run after 30 seconds of being commanded on.
    b. Fan fails to stop after 30 seconds of being commanded off.
    c. Software safety trip.
    d. Software safety lockout (4 safety trips in 3 hours).
    e. Low or high discharge air temperatures.
        1) If the discharge air temperature falls below 40°F (adjustable) in heating mode, open the heating hot water control valve, close the outdoor air damper and turn off all fans.
    f. Low or high space temperatures.

O. Fin-tube:
    a. Heating mode: Modulate control valve to maintain space temperature set point of 69°F – adjustable.
    b. Cooling mode: Modulate control valve to full closed position.
    c. Alarms:
        1) High/low space temperature.

3.2 DEMAND CONTROL VENTILATION – OCCUPIED MODES (DEMAND CONTROL): NOTE: THE CO2 SENSOR WITH THE HIGHEST PPM READING SHALL BE USED FOR SEQUENCE BELOW.

A. Overview:
    1. The HVAC system sequence of operations steps for normal thermal control is unchanged by incorporation of the outside air quantity/ventilation control sequences below. The control sequences below represent a function that will override the normal thermal controls as required to maintain outside air requirements during occupied modes.

2. During occupied modes the outside air damper shall never be positioned below the scheduled "standard occupancy minimum outdoor air" quantity (O.A. damper occupied minimum position) except in case of alarm.
3. Provide provision for extended commissioning (one year) to check calibration of CO^2 sensor, monitor/test CO^2 levels to ensure target person ventilation rates are met and maintained and the lag time is within the limit prescribed by ASHRAE 62.
4. Note: CO2 sensors shall work with DDC system to provide space CO2 level record keeping every 15 minutes for 3 years.
5. CO2 Concentration "Set Points":
   a. All Spaces: 530 ppm above ambient.

   Note: Outside air CO2 concentration shall be measured.
6. Equipment outside Air Damper Control:
   a. CO2 readings shall be compared to the CO2 set point. If the reading is less than 100 ppm above outside air CO2 level the DDC system shall maintain the base ventilation rate at the scheduled "standard occupancy minimum outdoor air" quantity (O.A. damper occupied minimum position). If the CO2 reading rises 100 ppm above outside air CO2 concentration then the DDC system shall start to modulate the outside air dampers open utilizing a proportional-integral (PI) loop to reduce the CO2 concentration in the space. The outside air damper shall be open for full occupancy when the CO2 level reaches the set point. Once the space CO2 level drops below 100 ppm above outside air CO2 level the outside air dampers shall move to maintain the scheduled "standard occupancy minimum outdoor air" quantity (O.A. damper occupied minimum position).
   b. If the DDC SYSTEM determines that it is beneficial to use additional outside air for cooling, then it shall override the demand controlled ventilation algorithm to modulate the dampers to an increased open position as required.
   c. START-UP PURGE CYCLE (30 MINUTES PRIOR TO OCCUPIED MODES): When the unit starts the outdoor air damper shall open initiating a timed purge cycle. The outdoor air damper shall modulate to maintain the mixed airflow with outside air percentage at 100% of full occupancy load. The purge period shall be adjustable and shall initially be set for 30 minutes.
   d. POST PURGE CYCLE (use prior to changing for occupied mode to un-occupied mode): System shall not change from occupied mode to unoccupied mode until space CO2 level drops to ambient level.

SECTION 230993

SECTION 231000 - VARIABLE TORQUE A-C DRIVE CONTROLLERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Variable frequency A-C drive controllers for mechanical equipment.

B. Furnish all labor, materials, equipment and service to perform all operations required for the complete installation and related work as required in all contract documents.

1.2 SUBMITTALS

A. Submit manufacturer's product data shop, drawings, samples, and installation instructions in accordance with the General Conditions.

B. Shop drawings of VFD, reactors, and wiring diagrams shall be provided with list of parts including fuses and breakers.

C. Contract Closeout Reports.

D. Project Record Documents.

E. Operation and Maintenance Data.

F. Warranty.

1.3 QUALITY ASSURANCE

A. The drives shall consist of two major performance-matched components. The VFD manufacturer shall furnish a Variable Torque AC Drive Controller and a performance matched energy efficient motor and will assume responsibility for matching the motor and controller.

B. The manufacturer of the VFD described in this specification shall have a minimum of twenty (20) years experience in the design, construction and application of adjustable frequency controls and motors.

C. The VFD manufacturer shall perform, but not be limited to, the following quality assurance controls, procedures and tests to insure VFD performance of ALL manufactured VFD controllers:
   1. Circuit Testing:
      a. All circuits are pre-burned tested for in-circuit component parameters and functional performance.
      b. All regulator, power supply, and keypad circuits are burned-in for 20 hours. This procedure consists of ten-two hour cycles during which the temperature is varied from -20C to +70C at the rate of 5C per minute. There are dwell times of 30 minutes (hot) and 58 minutes (cold) during each cycle.
      c. All burned-in circuits are post-burn tested for functional performance.
   2. Hi-Pot Testing:
      a. Post-assembly, all drives are subjected to high potential testing at 2,000 VAC, 2 milliamps maximum, for 1 second.
   3. Drive Setup and Functional Tests:
      a. SET-UP: the following VFD variables are factory set prior to shipping:
         1) Acceleration ramp
         2) Deceleration ramp
         3) MIN and MAX Speed
         4) Current limit

5) Volts / Hertz Ratio

b. FINAL TEST: the following VFD functional checks are made and verified prior to shipping:
   1) Fault and Function-loss circuit operation
   2) Auto-reset function
   3) Reversing function
   5) Load test using an actual motor at full speed and full load for five (5) minutes while phase currents, phase voltages and motor speed are monitored.

1.4 CODES AND STANDARDS

A. The VFD and all options shall be UL listed and so labeled. Additionally, the VFD Package when fully assembled with selected options into the common cabinet shall be UL listed and so labeled as a complete system.

B. AFC (Adjustable Frequency Controller) with all options shall comply with all applicable requirements of the latest standards ANSI; NEMA ICS 1, 2, 3 and 6; National Electrical Code (NEC); NEPU-70; IEEE P598.

C. AFC shall comply to IEEE-519-1993 standards and the VFD systems shall not produce more than 5% THD voltage waveform distortion on the power distribution system.

D. The AFC shall comply with Radio Frequency Noise Standard FCC Part15, Subpart J.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer's catalog numbers are used as illustrations. Similar products of the following manufacturers are acceptable equals. All similar items shall be by one manufacturer.
   1. ABB
   2. Square D
   3. Yaskawa

2.2 GENERAL

A. The variable torque AC drive shall consist of a solid-state adjustable frequency controller with all accessories and performed matched energy efficient motor manufactured by the same vendor.

B. The AFC shall convert voltage indicated on drawings, + 10%, 3 phase, 60 Hz utility power to an adjustable voltage/frequency, three phase, AC power for stepless motor control from 10% to 110% of base motor speed. The output waveform shall be an adjustable pulse width modulated using flux-vector control. Pulse width modulated types using IGBT Technology shall not be acceptable.

C. VFD shall be current rated at 8 kHz carrier frequency for VFD's 1-75 HP and 4 kHz for VFD's 100-400 HP. All HP ratings shall meet or exceed Table 430-150 of the National Electric Code. Three Phase Motor Full Load Currents, HP, Maximum Current, and Rated Voltage shall appear on the drive nameplate.

D. VFD shall not generate damaging voltage pulses at the motor terminals when applied within 500 feet of each other. Both Drive and Motor shall comply with NEMA MG1 section 30.40.4.2 which specifies these limits at a maximum peak.

2.3 DRIVE FUNCTIONS

A. The VFD shall have the following basic features:
   1. An electronic overload circuit designed to protect an AC motor operated by the VFD output from extended overload operation on an inverse time basis. This Electronic overload shall be ULä and NEC recognized as adequate motor protection. No additional hardware such as motor overload relays or motor thermostats shall be required.
   2. An LED display mounted on the door of the cabinet that digitally indicates:
      a. Frequency output
      b. Voltage output
      c. Current output
      d. Motor RPM
      e. Input kW
      f. Elapsed Time
      g. Time Stamped Fault Indication
      h. DC Bus Volts

B. The VFD shall have the capability of riding though power dips up to 10 seconds without a controller trip depending on load and operating condition. In this extended ride through, the drive shall use the energy generated by the rotating fan as a power source for all electronic circuits.

C. RS232 Port and Windows based software for Configuration, Control, and Monitoring.

D. An isolated 0-20mA, 4-20mA or 0-4, 0-8, 0-10 volt analog speed input follower.

E. An isolated 0-10 V or 4-20 mA output signal proportional to speed or load.

F. Provide a Modbus to BACnet interface card. Coordinate requirements with controls vendor.

2.4 PROTECTIVE CIRCUITS AND FEATURES

A. The VFD shall include the following protective circuits and features:
   1. Motor current exceeds 200% of drive continuous current rating.
   2. Output phase-to-phase short circuit condition.
   3. Total ground fault under any operating condition.
   4. High input line voltage.
   5. Low input line voltage.
   6. Loss of input or output phase.
   7. External fault. (This protective circuit shall permit wiring of remote N.C. safety contact to shut down the drive). User supplied end switches, thermal switches, fire-stats, freeze-stats inputs will be connected to this VFD supplied circuit.
   8. Metal oxide varistors for surge suppression shall be provided at the VFD input terminals.

2.5 GENERAL OPTIONS AND MODIFICATIONS

A. The following options shall be included as specified:
   1. Input line fuses shall provide protection for the input rectification circuit using Class J fuses with interrupting rating of 200,000 AIC. The series interrupting rating of the VFD and fuses shall be a minimum of 30,000 AIC and shall be stated in the VFD Instruction Manual as required by UL
   2. A main input disconnect shall mount within the standard NEMA 1 or NEMA 12 enclosure for positive power disconnect of the VFD. It shall have the capability for door padlocking.

3. A three phase 5% impedance Input Line Reactor shall be provided to minimize drive harmonics on the AC line and protect the drive from damaging electrical system transients.
4. Temperature Control System interface card for direct connection from the bus architecture. All configuration and control functions can be accessed through this card. Allows direct communication between the microprocessor and the host system. Fault diagnostics, start/stop, speed commands, and all drive feedback's shall be available over a single RS485 communication connection. Discrete signals such as Interlock Open shall also be mapped through the drive terminal strip to the system. The card shall have the ability to be used in a "monitor only" mode where control shall be from a AHU or similar type controller directly wired to the drive.
5. Provide manual bypass.

PART 3 - EXECUTION

3.1 INSTALLATION

A. VFD’s shall be furnished and programmed by the unit manufacture.

B. The VFD manufacturer shall maintain and staff local service engineers and must maintain a reasonable supply of spare parts for the VFD's to meet ordinary repair requirements within 100 miles of the installation site. Warehousing of spare parts shall be open to the Engineer for observation.

C. The manufacturer of the equipment provided shall warrant his equipment against defects in workmanship and parts failure for one (1) year form date of start-up. This warranty shall cover all parts, labor and travel related expenses.

END OF SECTION 23 1000

SECTION 232113 - HYDRONIC 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 pipe and fitting materials and joining methods for the following:
   1. Hot-water heating piping.
   2. Blowdown-drain piping.
   3. Air-vent piping.
   4. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Plastic pipe and fittings with solvent cement.
   2. RTRP and RTRF with adhesive.
   3. Pressure-seal fittings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, 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. Other building services.
   3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied from the same manufacturer as the grooved components.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Blowdown-Drain Piping: 200 deg F.
3. Air-Vent Piping: 200 deg F
4. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Copper or Bronze Pressure-Seal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Viega.
2. Housing: Copper.
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer's special tools.
5. Minimum 200-psig working-pressure rating at 250 deg F.

E. Wrought-Copper Unions: ASME B16.22.

F. Grooved Mechanical-Joint Couplings and Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Victaulic Company.
2. Joint Fittings: ASME B16.22 wrought copper or ASME B16.18 bronze castings with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).
3. Couplings: Ductile-iron housings cast with offsetting, angle-pattern bolt pads coated with copper-colored enamel and Grade “EHP” EPDM gasket of central cavity pressure-responsive design suitable for hot water up to 250 deg F; with plated steel nuts and bolts to secure grooved pipe and fittings. Couplings shall be “Installation Ready” stab-on design, for direct ‘stab’ installation onto roll grooved copper tube without prior field disassembly and no loose parts.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Victaulic Company.
   2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   3. Couplings: Ductile-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
      a. Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with ASME B31.1 and B31.9.
         1) 2” through 8”: “Installation Ready” stab-on design, for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose parts with Grade “EHP” EPDM gasket suitable for hot water up to 250 deg F.
         2) 10” and 12”: Standard rigid coupling with Grade “E” EPDM gasket suitable for hot water up to 230 deg F.
      b. Flexible Type: Use in seismic areas and locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors for vibration isolation at equipment connections. Three (3) couplings, for each connector, shall be placed in close proximity to the source of vibration.
         1) 2” through 8”: “Installation Ready” stab-on design, for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose parts with Grade “EHP” EPDM gasket suitable for hot water up to 250 deg F.
         2) 10” and 12”: Standard flexible coupling with Grade “E” EPDM gasket suitable for hot water up to 230 deg F.

I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      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.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon 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 joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. A.Y. McDonald Mfg. Co.
      b. Capitol Manufacturing Company.
      c. Central Plastics Company.
      d. Hart Industries International, Inc.
      e. Jomar International Ltd.
      f. Matco-Norca.
      g. Watts Regulator Co.
      h. Zurn Industries, LLC.
   2. Description:
      a. Standard: ASSE 1079.
      b. Pressure Rating: 250 psig
      c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. 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. Matco-Norca.
      d. Watts Regulator Co.
      e. Zurn Industries, LLC.
   2. Description:
      a. Standard: ASSE 1079.
      b. Factory-fabricated, bolted, companion-flange assembly.

c. Pressure Rating 300 psig
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
2. Description:
a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 300 psig
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Elster Perfection.
b. Victaulic Company.
2. Description:
a. Standard: IAPMO PS 66.
b. Electroplated steel or ductile iron nipple, complying with ASTM F 1545.
c. Pressure Rating: 300 psig at 230 deg F.
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be the following:
1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered and pressure-seal joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger range, shall be the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Hot-water heating piping installed belowground and within slabs shall be the following:
1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

D. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

E. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges or grooved mechanical-joint couplings in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

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

G. Grooved mechanical-joint rigid couplings may be used with IPS steel piping systems, which meet the support and hanging requirements of ASME B31.1 and B31.9. An adequate number of flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel or groove plain ends of steel pipe.

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

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

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

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

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

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

J. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

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SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 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 special-duty valves and specialties for the following:
1. Hot-water heating piping.
2. Chilled-water piping.
3. Glycol cooling-water piping.
4. Makeup-water piping.
5. Condensate-drain piping.
6. Blowdown-drain piping.
7. Air-vent piping.
8. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: 150 psig at 200 deg F

2. Chilled-Water Piping: 150 psig at 200 deg F
3. Glycol Cooling-Water Piping: 150 psig at 150 deg F.
4. Makeup-Water Piping: 80 psig at 150 deg F
5. Condensate-Drain Piping: 150 deg F
6. Blowdown-Drain Piping: 200 deg F
7. Air-Vent Piping: 200 deg F
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
   f. Nexus Valve, Inc.
   g. Taco.
   h. Tour & Andersson; available through Victaulic Company.
2. Body: Bronze or Ametal (copper-alloy), ball, globe, or plug type with calibrated orifice or venturi
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE or EPDM.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 250 psig.
10. Maximum Operating Temperature: 230 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
   f. Taco.
   g. Tour & Andersson; available through Victaulic Company.
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.

1. Disc: Ametal (copper-alloy) or glass and carbon-filled PTFE.
2. Seat: PTFE.
3. End Connections: Flanged or grooved.
4. Pressure Gage Connections: Integral seals for portable differential pressure meter.
5. Handle Style: Handwheel, Lever, with memory stop to retain set position.
6. CWP Rating: Minimum 250 psig.
7. Maximum Operating Temperature: 230 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: bronze, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: bronze, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Flow Design Inc.
b. Griswold Controls.
c. Nexus Valve, Inc.
d. Victaulic Company

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig
9. Maximum Operating Temperature: 250 deg F.

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.
e. Taco, Inc.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.
e. Taco, Inc.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Diaphragm or Bladder-Type Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Amtrol, Inc.

b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Taco, Inc.

2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Taco, Inc.
e. Spirotherm.
2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

E. Air Purgers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Taco, Inc.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.4 HYDRONIC PIPING SPECIALTIES

A. 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 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

B. Y-Pattern Grooved End Strainers:

1. Body: Ductile iron body with blow-down port fitted with pipe plug.
2. End Connections: Grooved

3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 300 psig (2068 kPa).

C. 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 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. 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.

E. Stainless-Steel Bellow, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

F. Spherical, Rubber, Flexible Connectors:
1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

G. Expansion Fittings: Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping."Section 15124 "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

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

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. 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.
   2. Suction Lines for Heat-Pump Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

1.4 ACTION 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: 1/4 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.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 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."

1.8 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.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

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. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:
   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 misalignment in minimum 7-inch-long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig.
   5. Maximum Operating Temperature: 250 deg F.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. 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.

E. Flanged Unions:
   1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.

2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
6. Pressure Rating: Factory test at minimum 400 psig.
7. Maximum Operating Temperature: 330 deg F.

F. Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:
   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 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.
7. Maximum Operating Temperature: 275 deg F.

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.
8. Maximum Operating Temperature: 275 deg F.

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.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

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.

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 conduit adapter, and 24-V ac coil.
   6. Working Pressure Rating: 400 psig.
   7. Maximum Operating Temperature: 240 deg F.
   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.
   6. Maximum Operating Temperature: 240 deg F.

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.
   6. Superheat: Adjustable.
   7. Reverse-flow option (for heat-pump applications).
   8. End Connections: Socket, flare, or threaded union.
   9. Working Pressure Rating: 450 psig.

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.
   7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
   8. End Connections: Socket.
   9. Throttling Range: Maximum 5 psig.
   10. Working Pressure Rating: 500 psig.
   11. Maximum Operating Temperature: 240 deg F.

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.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with 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.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with 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.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

N. Receivers: Comply with 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.
7. Maximum Operating Temperature: 275 deg F.

O. 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.
4. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

A. 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.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle 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 or packed-angle 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 piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or

panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. 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.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "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 long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. 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 with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Single-wall rectangular ducts and fittings.
2. Single-wall round and flat-oval ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Duct Lining.

B. Related Sections:
1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. All ductwork in the pool and spectator area shall be constructed of aluminum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
1. Sealants and gaskets.

B. Shop Drawings:
1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Equipment installation based on equipment being used on Project.
9. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
10. Hangers and supports, including methods for duct and building attachment**,** seismic restraints**,** and vibration isolation.

C. Delegated-Design Submittal:
1. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
   2. Suspended ceiling components.
   3. Structural members to which duct will be attached.
   4. Size and location of initial access modules for acoustical tile.
   5. Penetrations of smoke barriers and fire-rated construction.
   6. Items penetrating finished ceiling including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/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.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND 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:
      a. Lindab Inc.
      b. McGill AirFlow LLC.
      c. SEMCO Incorporated.
      d. Sheet Metal Connectors, Inc.
      e. Spiral Manufacturing Co., Inc.

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 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches 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 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

D. 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.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. 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. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
12. Service: Indoor or outdoor.
13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.6 DUCT LINER

A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA Inc.
   b. Armacell LLC.
   c. Rubatex International, LLC
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 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.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
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.

D.

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 and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

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.

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 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."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 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. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.7 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 of 2-Inch wg or Higher: Test representative duct sections**,** selected by Engineer from sections installed, totaling no less than 50 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 seven days' advance notice for testing.

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

D. Prepare test and inspection reports.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
1. Underground Ducts: Concrete-encased, stainless steel.

B. Supply Ducts:
1. Ducts Connected to Fan Coil Units and Terminal Units:
a. Pressure Class: Positive 2-inch wg
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Constant-Volume Air-Handling Units:
a. Pressure Class: Positive 3-inch wg
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
a. Pressure Class: Positive or negative 2-inch wg
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Air-Handling Units:
a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
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.
b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.

c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 12**.**

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative 1-inch wg.
   b. Minimum SMACNA Seal Class**:** C.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

F. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
2. Stainless-Steel Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.
3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

G. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 3113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Duct silencers.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

B. Related Requirements:
1. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. American Warming and Ventilating; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   4. Greenheck Fan Corporation.
   5. Lloyd Industries, Inc.
   6. Nailor Industries Inc.
   7. NCA Manufacturing, Inc.
   8. Pottorff.
   9. Ruskin Company.
   10. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm

D. Frame: Hat-shaped, 0.05-inch- thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch- thick, roll-formed aluminum with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Extruded vinyl, mechanically locked.

H. Blade Axles:
1. Material: Nonferrous metal.
2. Diameter: 0.20 inch.

I. Return Spring: Adjustable tension.

2.4 BAROMETRIC RELIEF DAMPERS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.

C. Suitable for horizontal or vertical mounting.

D. Maximum Air Velocity: 1250 fpm.

E. Maximum System Pressure: 3-inch wg.

F. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel with welded corners or mechanically attached and mounting flange.

G. Blades:
1. Multiple, 0.025-inch- thick, roll-formed aluminum.
2. Maximum Width: 6 inches.
3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted, Off-center pivoted, or End pivoted.

H. Blade Seals: Neoprene.

I. Blade Axles: Galvanized steel or Stainless steel.

J. Tie Bars and Brackets:
1. Material: Galvanized steel.
2. Rattle free with 90-degree stop.

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic or Stainless steel.

M. Accessories:
1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products 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. Flexmaster U.S.A., Inc.
      d. McGill AirFlow LLC.
      e. Nailor Industries Inc.
      f. Pottorff.
      g. Ruskin Company.
      h. Trox USA Inc.
      i. Vent Products Company, Inc.
   2. Standard leakage rating.
   3. Suitable for horizontal or vertical applications.
   4. Frames:
      a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized-steel, 0.064 inch thick.
   6. Blade Axles: Galvanized steel.
   7. Bearings:
      a. Stainless-steel sleeve.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products 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. Nailor Industries Inc.
      e. Pottorff.
      f. Ruskin Company.
      g. Trox USA Inc.
      h. Vent Products Company, Inc.
   2. Standard leakage rating.
   3. Suitable for horizontal or vertical applications.
   4. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.

e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

6. Blade Axles: Stainless steel.
7. Bearings:
   a. Stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products 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. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
   g. Trox USA Inc.
   h. Vent Products Company, Inc.
2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Hat shaped.
   b. 0.094-inch- thick, galvanized sheet steel.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized, roll-formed steel, 0.064 inch thick.
7. Blade Axles: Galvanized steel.
8. Bearings:
   a. Oil-impregnated stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:
   a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products 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. Nailor Industries Inc.

e. Pottorff.
f. Ruskin Company.
g. Trox USA Inc.
h. Vent Products Company, Inc.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   d. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
7. Blade Axles: Stainless steel.
8. Bearings:
   a. Oil-impregnated stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Aluminum.
12. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:
1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

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. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. McGill AirFlow LLC.
7. Metal Form Manufacturing, Inc.
8. Nailor Industries Inc.

9. NCA Manufacturing, Inc.
10. Pottorff.
11. Ruskin Company.
12. Vent Products Company, Inc.
13. Young Regulator Company.

B. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:
1. Hat shaped.
2. 0.094-inch- thick, galvanized sheet steel.
3. Mitered and welded corners.

D. Blades:
1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Galvanized-steel.
4. 0.064 inch thick single skin.
5. Blade Edging: Closed-cell neoprene.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:
1. Stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide 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. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Nailor Industries Inc.
6. NCA Manufacturing, Inc.
7. Pottorff.
8. Prefco; Perfect Air Control, Inc.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Static; rated and labeled according to UL 555 by an NRTL.

C. Fire Rating: 1-1/2 and 3 hours.

D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.138 inch 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.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

J. Heat-Responsive Device: replaceable link and switch package, factory installed, 165 deg F rated.

2.8 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Dynasonics.
2. Greenheck.
3. Industrial Noise Control, Inc.
4. McGill AirFlow LLC.
5. Ruskin Company.
6. Vibro-Acoustics.

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.

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**] [**G60**], galvanized sheet steel, [**0.034 inch**] [**0.040 inch**] thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, [**G90**] [**G60**], galvanized sheet steel.
1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, [**G90**] [**G60**] galvanized sheet metal, 0.034 inch thick, and with 1/8-inch- diameter perforations.

G. Special Construction:
1. Suitable for outdoor use.

2. High transmission loss[**to achieve STC 45**].

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**] [**Film-lined**] type with fill material.
   a. Fill Material: [**Inert and vermin-proof fibrous material, packed under not less than 5 percent compression**] [**Inert and vermin-proof fibrous material, packed under not less than 15 percent compression**] [**Moisture-proof nonfibrous material**].
   b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
3. Lining: [**None**] [**Mylar**] [**Tedlar**] [**Fiberglas cloth**] <**Insert material**>.

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. Joints: [**Lock formed and sealed**] [**continuously welded**] [**or**] [**flanged connections**].
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. Integral [**1-1/2**] [**3**]-hour fire damper with access door.[**Access door to be high transmission loss to match silencer.**]
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow measuring devices.

L. Source Quality Control: Test according to ASTM E 477.
1. Testing [**of mockups**]to be witnessed by [**Architect**] [**Owner**].
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

M. Capacities and Characteristics:
1. Configuration: [**Straight**] [**90-degree elbow**] <**Insert configuration**>.
2. Shape: [**Rectangular**] [**Round**].
3. Attenuation Mechanism: [**Acoustical glass fiber**] [**Acoustical glass fiber with protective film liner**] [**Helmholtz resonator mechanism with no internal media**].
4. Maximum Pressure Drop: [**0.35-inch wg**] <**Insert value**>.
5. Casing:
   a. Attenuation: [**Standard**] [**High transmission loss**].
   b. Outer Material: [**Galvanized steel**] [**Stainless steel**] [**Aluminum**].
   c. Inner Material: [**Galvanized steel**] [**Stainless steel**] [**Aluminum**].
6. Velocity Range: <**Insert fps**> to <**Insert fps**>.
7. End Connection: [**1-inch slip joint**] [**Flange**].
8. Length: <**Insert inches**>.
9. Face Dimension:
   a. Width: <**Insert inches**>.
   b. Height: <**Insert inches**>.
10. Face Velocity: <**Insert fpm**>.
11. Dynamic Insertion Loss: <**Insert dBA**>.

12. Generated Noise: <**Insert dBA**>.
13. Accessories:
    a. Access door.
    b. Birdscreen.

2.9 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. Elgen Manufacturing.
4. METALAIRE, Inc.
5. SEMCO Incorporated.
6. 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. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.10 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. Ductmate Industries, Inc.
4. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.
10. Ventfabrics, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
    a. Double wall, rectangular.

b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.11 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. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. 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 wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

I. 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 movement at start and stop.

2.12 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, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
   1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 to plus 175 deg F.
   4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or Nylon strap in sizes 3 through 18 inches, to suit duct size.
   2. Non-Clamp Connectors: Adhesive.

2.13 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 backdraft 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 security bars. Construct duct security bars from 0.164-inchsteel sleeve, continuously welded at all joints and 1/2-inch- diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.

I. Connect ducts to duct silencers with flexible duct connectors.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream or downstream from duct silencers.
   9. Control devices requiring inspection.
   10. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.
   3. Head and Hand Access: 18 by 10 inches.
   4. Head and Shoulders Access: 21 by 14 inches.
   5. Body Access: 25 by 14 inches.
   6. Body plus Ladder Access: 25 by 17 inches.

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

Q. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

R. Connect flexible ducts to metal ducts with adhesive and draw bands.

S. Install duct test holes where required for testing and balancing purposes.

T. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.
   5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 23 3513 – DUST COLLECTORS FOR WOODWORKING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes wood dust collector – outdoor filter type with direct drive fan and funnel bottom – with spark detection and extinguishing system.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and includes 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 gages and finishes.

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. Differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Show layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support.

D. Operating and Maintenance Data.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver dust collector as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.4 COORDINATION

A. Coordinate size and location with associated systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Sternvent Company.
   2. Donaldson Torit
   3. Approved equal.

2.2 UNIT REQUIREMENTS

A. Furnish and install, where shown on the plans, a high efficiency filter type dust collector with integral blower sized for design air flow as shown on the schedule.

B. Dust collector shall be self-cleaning fabric type complete with cotton filters, backward inclined blower, motorized shaker, factory wired controller and external discharge silencer. Manufacturer's literature shall state that dust collector and selected filter spacing is designed for the collection of wood dust.

Dust collector shall be airtight, all steel construction with sealed seams and gasketed quick-opening doors with ¼ turn knobs. Housing shall be minimum of 14-ga. mild steel. Unit shall consist of a filter section, with sloped roof to shed rain and pyramid bottom section without slide gates or doors to allow downflow of dust directly into 55-gallon drum assemblies furnished by manufacturer. Inlet, with baffle, shall be centered on rear of unit for even distribution of dust to the drums. Designs with inlet on narrow side shall not be accepted. Include an explosion relief vent, in the dirty section of the filter housing, per NFPA #68 and #664.

C. Unit to include a multi-pocket filter module, which is sewn from 8-ounce cotton sateen fabric designed to deliver in excess of 99.5% efficiency by weight on industrial dusts. The filter module shall have rigid insert separators to prevent collapse of filters and loss of effective filter area. Flat shaker fingers located at the bottom of the filter module shall prevent adjoining pockets from touching one another and blanking off. The filter pocket spacing shall be of the wide spacing type (1-1/2") to permit the collected dust to be shaken off the filters freely and recommended by the manufacturer for the collection of wood dust. Fabric media with narrow spacing or pleated cartridges will not be accepted. Total airflow to filter fabric area (air to cloth ratio) shall not exceed 10 CFM per square foot.

Each filter module shall be secured in place by two lever, operated over-center, locking mechanisms to assure a positive seal and allow for easy removal of filters from outside of unit, without tools. Designs which require entry into unit (confined space), for filter maintenance, are not acceptable.

D. Filters will be cleaned automatically after a fifteen second delay following the shutdown of the blower, by the oscillating action delivered by the motorized eccentric driven shaker assembly, which imparts a vibratory force throughout the entire surface of each individual filter pocket to dislodge the dust.

Operation of the automatic shaker shall be controlled by a solid state, dual mode timer with adjustable shaker cycle range from 1.8 – 180 seconds. Magnetic starters with overload relays for the blower and shaker motor and control transformer shall be factory wired in a NEMA 4 control panel mounted on the unit for single point wiring. Also included shall be a push button station for remote mounting.

E. The control panel wiring shall be either UL or ETL labeled for compliance with 508A. Control panels not labeled by dust collector manufacturer shall be labeled, in field, by a certified UL or ETL representative, prior to placing equipment in operation.

F. The integral non-sparking AMCA Type C direct drive blower shall be located on the clean air side of the filters, top mounted at the factory and be of the backward inclined design with a dynamically balanced impeller. It shall be driven by a 3450 RPM, TEFC motor (HP shown on schedule). The blower shall be tested in accordance with AMCA Standard 210. A factory-supplied cover shall protect the motor cooling fan from ice.

G. Discharge noise from the blower shall be attenuated by an external field supported duct silencer fabricated with 4.75 lb. density inorganic mineral or glass fiber. This media shall be protected from erosion by the air flow through the use of galvanized perforated metal with aerodynamic leading and trailing edges to insure maximum acoustical insertion loss at minimum static pressure drop.

H. Interior and exterior carbon steel surfaces shall be painted with one (1) coat of heat cured gray powder spray or interior and exterior primed with red oxide and exterior finished with alkyd resin gray enamel paint.

2.3 SPARK DETECTION AND EXTINGUISHING SYSTEM (TYPICAL FOR EACH INSTALLATION)

A. The system shall be as manufactured by FLAMEX Inc.

B. Provide Two (2) Infrared Spark Detectors capable of detecting IR in .78 to 1.2 micron range. Sensors must be housed in a metal IP 65 enclosure and come complete with Stainless Steel mounting hardware. Sensors must be easily removable from the duct for maintenance inspections. Detector Lens must be removable and replaceable if damaged. Detector shall feature an external LED to blink when activated to facilitate maintenance inspections. Detectors shall come equipped with stainless steel wire inlet connectors. Detectors must be suitable for outdoor use in temperatures ranging from –30 Degrees C to 80 Degrees C.

C. Provide One (1) 1” Extinguishing Assembly complete with 12 VDC Solenoid Valve, Brass Y Strainer with Stainless Steel Screen, and Ball Valve with Locking Strap, Lock and Key. The Solenoid Valve shall be the slow closing type to eliminate water hammer. A Stainless Steel Directional Spray Nozzle shall be provided as part of this Assembly, which will produce a 180-degree Fan Shaped Spray Pattern. Stainless Steel mounting hardware for Nozzle shall also be provided. The Extinguishing Assembly must be capable of flowing a minimum of 17 GPM at 44 PSI flowing pressure at the solenoid valve.

D. A remote 110V AC audible and visual alarm shall be provided to annunciate all system activations

E. An external test light system to include test light controller and one (1) external test light (IR emitter) per duct shall be provided for testing of the sensors. The test light controller shall feature a variable intensity dial to vary the intensity of IR emitted for testing. Internal test lights will not be acceptable.

F. Control Panel shall be the FLAMEX FMZ-5000 Multi Zone Console. Incoming Power requirement shall be 110/60/1. The panel shall include battery to provide emergency back-up power for a minimum of 24 Hours to the panel in the event of loss of incoming power. The panel shall feature programmable shutdown capability for the interlocking or fans and associated equipment. The control panel shall have a 24V strobe with a 105dB audible horn indicating activation of the extinguishing system. Control panel shall have LCD display. Event memory shall be accessible through LCD display.

G. Options:
   1. External test light system. System shall perform automated tests at preprogrammed intervals. Coordinate interval with Owner.
   2. Pre plumbed flow monitor for leakage indication and alarming on failure to flow.

H. The System shall be Factory Mutual Approved.

2.4 DUST SWITCH

A. The system shall be as manufactured by Sternvent, or approved equal.

B. Electrically interlock each woodworking machine with the dust collector so that, when a machine is turned on, the dust collector starts automatically. Include manual override to permit use of floor sweeps without having any equipment energized.

C. Electrically interlock with BC-1 and 2, when dust collector is on BC-1 and BC-2 shall provide ventilation air for the shop.

D. Provide a start/stop station with 2-position selector switch (automatic/manual) and an adjustable delay timer that will keep the dust collector on for 15 – 120 seconds after the last machine is switched off, to minimize dust collector cycling and allow the dust in the duct system to be evacuated.

E. All wiring shall be centralized at the circuit breaker panel for ease of installation and expansion for future machines. The interlock shall not require hard wiring at the machines, modification of the motor starters, or special auxiliary contacts.

F. The dust switch shall be UL listed and labeled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Install units with clearances for service and maintenance.

C. Label equipment according to specified requirements

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.

B. Install ducts adjacent to dust collector to allow service and maintenance.

C. Ground equipment.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:
   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. Verify lubrication for bearings and other moving parts.

B. Starting Procedures:
   1. Energize motor and adjust fan to indicated rpm.
   2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

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

E. Shut unit down and reconnect automatic temperature-control operators.

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

G. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris.

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

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain wood dust collector.
   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
   2. Review data in maintenance manuals.
   3. Delete subparagraph above or below depending on which Section is retained in Division 1.
   4. Review data in maintenance manuals.
   5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 23 3513

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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. Rectangular and square ceiling diffusers.
2. Fixed face grilles**.**
3. Drum Diffuser.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Anemostat Products; a Mestek company.
b. Krueger.
c. METALAIRE, Inc.

d. Nailor Industries Inc.
e. Price Industries. – Basis of design
f. Titus.

2.2 REGISTERS AND GRILLES

A. Fixed Face Grille And Drum Diffuser:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Anemostat Products; a Mestek company.
b. Krueger.
c. Nailor Industries Inc.
d. Price Industries. – Basis of design
e. Titus.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713

SECTION 236416 - CENTRIFUGAL WATER CHILLERS – AIR COOLED

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes design, performance criteria, refrigerants, controls, and installation requirements for air cooled centrifugal chiller CH-MAN-1.

1.2 REFERENCES

Compliance is with the following codes and standards:

1. AHRI 550/590
2. ANSI/ASHRAE 15
3. ASME Section VIII
4. ETL Listed
5. ANSI UL 1995
6. CSA C22.2 No. 236 (Canada)

1.3 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 506/110 and referenced to ARI standard rating conditions.

E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 506/110 and intended for operating conditions other than the ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

A. Unit shall consist of one or more magnetic bearing oil-free centrifugal compressors with integrated variable frequency drive, refrigerant flooded evaporator, air cooled condenser, and operating controls with equipment protection.

B. Performance: Refer to schedule for specific operating conditions

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude. Site altitude for this installation is 700-feet.

D. Acoustics: Sound pressure for the unit shall not exceed 92 dBa at three feet and shall represent the highest levels recorded at all load points. Sound data shall be measured according to ARI 575-87.

E. Chiller shall be equipped for single-point power connection.

F. Performance Tolerance: Comply with the following in lieu of ARI 506/110:

1. Allowable Capacity Tolerance: Standard AHRI tolerance applies.
2. Allowable IPLV/NPLV Performance Tolerance: Standard AHRI tolerance applies.

1.5 SUBMITTALS

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

1. Dimensioned plan and elevation drawings, including required service clearances and location of all field piping and electrical connections.

2. Acoustical performance.

3. Performance at ARI standard conditions and at conditions indicated.

4. Electrical and water quality requirements during operation, standby and shutdown.

5. Control system diagram showing points for field interface and connection to external BMS systems. Drawings shall show field and factory wiring.

6. Installation and Operating Manuals

7. Minimum and Maximum evaporator flow rate.

8. Refrigerant capacity of chiller.

9. Fluid capacity of evaporator, condenser.

10. Characteristics of safety relief valves.

11. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, and methods of field assembly, components, and location and size of each field connection.
12. Wiring Diagrams: For power, signal, and control wiring.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Manuals: For each chiller to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 550 certification program.

B. ARI Rating: Rate chiller performance according to requirements in ARI 506/110.

C. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.

F. Comply with National Electrical Code.

G. Comply with requirements of ETL, and include label by a qualified testing agency showing compliance.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

B. Package chiller for domestic shipping with a North America destination. Export packaging and shipping is available.

1.9 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

    a. Complete chiller including refrigerant.
    b. Complete compressor and drive assembly including refrigerant.
    c. Parts and Labor
    d. Loss of refrigerant charge for any reason.

2. Warranty Period:
    a. One Year Parts and Labor from date of Substantial Completion.
    b. Five-year parts only.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with project requirements, provide equipment by one of the following manufacturers.
1. Arctic Cool Chillers, Toronto, Canada; Newberry, South Carolina
2. TRANE
3. Smardt Chiller Group, Montreal Canada
4. Approved equal

2.2 MANUFACTURED UNIT

A. Description: Factory-assembled and tested chiller complete with compressor, compressor motor, compressor chiller controller, evaporator, condenser, controls, interconnecting unit piping and wiring, and indicated accessories.

B. Chiller Frame and Housing - All components shall be mounted onto a unitized construction, having Epoxy painted welded steel frame suitable for outdoor installation. Compressors and controls shall be contained within a sheet metal enclosure to protect critical components from the weather.

C. DESIGN REQUIREMENTS

1. Unit shall consist of one or more magnetic bearing oil-free centrifugal compressors with integrated variable frequency drive, refrigerant flooded evaporator, water cooled condenser, and operating controls with equipment protection. Manufacturers must provide a minimum of 3 compressors per chiller, and provide AHRI-Certified products only.

2. Performance: Refer to schedule for specific operating conditions. When utilizing Turbocor model TT300 compressors (85 nominal tons), the chiller shall be capable of stable operation down to 20 tons, model TT350 compressors, stable operation down to 35 tons.

All ratings are measured at standard AHRI entering condenser air temperatures and without utilizing hot gas bypass.

3. Acoustics: Sound pressure for the unit shall not exceed 72.5 dB(A) for TT300 compressors and 81 dB(A) for TT400 compressors measured at 1 meter (3.28 feet) and shall represent the highest levels recorded at all load points. Sound data shall be measured according to AHRI Standard 575-87.

4. Chiller shall be equipped for single-point power connection, unless otherwise specified.

5. In order to allow for variable chilled water flow and to facilitate chilled water pump energy savings the evaporator shall be designed to allow the flow rate to be reduced to 1 gpm per ton without entering laminar flow. The chiller shall be able to operate in a stable manner at this condition for at least 8 hours continuously, and independent of condenser water flow rate or condenser water temperature relief.

6. Each compressor shall be electrically and mechanically isolated so that if a compressor fails or needs service, it can be serviced or removed from the chiller without disabling the other compressors or the chiller, and allowing the chiller to remain in operation with the other compressor(s) on-line.

7. The chiller shall be provided with at least the number of compressors shown on the schedule. Manufacturers bidding chillers with a lesser number of compressors than shown on the schedule or provided in this section, shall provide (2) chillers at half the scheduled capacity and flow rates. It will be the manufacturer's responsibility to coordinate space and piping requirements with the contractor.

8. HCFC Refrigerant Written Guarantee - If manufacturer offers a chiller using any HCFC refrigerant, manufacturer shall provide, in writing, documentation signed by an officer of the company assuring refrigerant availability and price schedule for a 20-year period.

9. Positive Pressure Operation - The entire chiller system, including all pressure vessels, shall remain above atmospheric pressure during all operating conditions and during shut down to ensure that non-condensables and moisture do not contaminate the refrigerant and chiller system. If any portion of the chiller system is below atmospheric pressure during either operation or shut down, the manufacturer shall include, at no charge:
   a. A 20-year purge maintenance agreement that provides parts, labor, and all preventative maintenance required by the manufacturer's operating and maintenance instructions.
   b. A complete purge system capable of removing non-condensables and moisture during operation and shut-down.
   c. The manufacturer shall also include at no charge for a period of 20 years an annual oil and refrigerant analysis report to identify chiller contamination due to vacuum leaks. If the analysis identifies water, acid, or other contaminant levels higher than specified by the manufacturer, the oil and/or refrigerant must be replaced or returned to the manufacturer's original specification at no cost to the owner.
   d. The manufacturer shall include a factory-installed and wired system that will enable service personnel to readily elevate the vessel pressure during shutdown to facilitate leak testing.

2.3 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.

B. Compressor:
1. Compressors shall be of semi-hermetic centrifugal design and operate oil-free with two-stages of compression, magnetic bearings, movable inlet guide vanes and integrated variable frequency drive system.
2. Automatically positioned and controlled inlet guide vanes shall operate with compressor speed controls
3. The compressor shall be capable of coming to a controlled stop in the event of a power failure. The unit shall be capable of initializing an automatic restart in the case of a power failure
4. Each compressor shall have integrated microprocessor control capable of capacity and safety
5. Each compressor shall be installed with individual suction, discharge and motor cooling refrigerant line isolation valves. Chillers without discharge line isolation valves that rely on non-return valves in the discharge line for compressor removal shall not be accepted.
6. Each compressor shall have an individual disconnect switch. The compressor shall have mechanical and electrical isolation to allow the chiller to operate when a compressor is removed from the machine, on chillers that are provided with more than one compressor.
7. Compressor motor and chiller unit shall include variable-frequency speed controls to match cooling load demand to compressor speed and inlet guide vane position.
8. Each compressor shall be equipped with an AC line reactor and individual disconnect.
9. Compressors that need oil will not be accepted.

2.4 REFRIGERATION

A. Refrigerant:

1. Type: 134a.
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Chillers that operate on negative-pressure R-123, shall be capable of future refrigerant phase-out replacement. Chillers shall have evaporators and condensers that are ASME Section VIII Certified and bear the stamp.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

2.5 EVAPORATOR

A. Description: The evaporator shall be shell-and-tube flooded type with refrigerant in the shell and water inside the tubes. Heat exchangers shall be designed, constructed, tested and stamped in accordance with the requirements of ASME Code, Section VIII Code Case 1518-5. Heat exchanger

tubing shall have a copper wall thickness of 0.025 in. The water sides shall be designed for a minimum of 145 psig or as specified. The water connections for the evaporator and condenser shall be either grooved suitable for Victaulic couplings or flanged as detailed herein. Vents and drains shall be provided. The refrigerant side of each vessel shall bear the ASME Code stamp, code case section VIII. Vessels shall pass a test pressure of 1.1 times the working pressure but be not less than 100 psig. Provide intermediate tube supports spaced to enable equal liquid and gas flow across multiple compressor suction ports.

B. Tubes shall be individually replaceable and have internally and externally enhanced surfaces designed for refrigeration duty. Tubes shall have smooth full tube wall landings at the tube-sheet ends and at intermediate tube supports. Tubing without full wall thickness landings shall not be accepted. Tubes shall be mechanically roller expanded into steel tube sheets containing a minimum of three concentric grooves

C. To ensure effective liquid droplet removal, prevent liquid damage to compressors, and equalize suction pressure across evaporators with multiple compressors, a perforated plate designed for vapor disengagement shall be installed inside the evaporator above the tubing.

D. The evaporator shall be provided with spring loaded reseating-type pressure relief valves according to ASHRAE-15. Rupture disks are not acceptable.

E. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

F. Designed to prevent liquid refrigerant carryover from entering compressor.

G. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.

H. Minimum evaporator exiting water temperature shall be 38°F, unless otherwise specified and accepted by the chiller manufacturer.

I. Factory-mounted and wired water flow switches shall be provided on the evaporator in order to prevent unit operation with no water flowing through the heat exchangers.

2.6 AIR COOLED CONDENSER

A. To provide normal and energy efficient operation in the widest range of ambient temperatures air-cooled chillers shall have dedicated and discrete refrigeration circuiting for each compressor. Air cooled packaged chillers and controls shall be capable of reliable operation between 32°F and 110° ambient air temperature. Chillers that have more than one compressor sharing a single circuit and set of refrigerant controls shall not be acceptable.

B. Air-cooled condensers shall utilize aluminum fins with refrigeration duty copper tubes mechanically expanded into fin collars. Condenser coils shall be arranged in a W-configuration to reduce equipment footprint.

C. Condenser coils and fans shall be arranged such that one fan operates with one coil section so that the failure of a fan will not affect the CFM across any coil beyond that fan.

D. Condenser shall be equipped with a liquid line and mechanical float to ensure liquid sub-cooling necessary for effective cooling of the compressor.

E. Condenser shall be equipped with packaged fixed or variable speed fans capable of delivering specified CFM of air according to ARI standard operating conditions.

F. Fans shall be EC type with built-in variable-speed motors. To increase coil efficiency and reduce air recirculation, fans shall be rated for 16,000 nominal CFM at full speed. Fans and assemblies shall be designed to operate at reduced noise levels. Fans shall be balanced dynamically and statically and utilize direct variable-speed drives. Fan blades shall be manufactured with corrosion resistant materials. Fan assemblies shall utilize full airfoil cross section design, providing vertical

air discharge from extended orifices. The guards shall be constructed of heavy duty 14 gauge steel and painted. Fans shall be equipped with factory installed fan diffusers to reduce fan noise and increase power efficiency.

G. Refrigerant Economizer – Each dedicated refrigerant circuit shall include refrigerant components dedicated fan arrays. In order to assure reliable and efficient operation in higher ambient temperatures, each refrigeration circuit shall include a refrigerant to refrigerant brazed plate heat exchanger to provide cooled refrigerant gas injection between compressor impeller stages.

2.7 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Thickness: ¾”

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

2.8 LIQUID LEVEL CONTROLS

A. Control of refrigerant flow shall utilize a single or multiple 6,000 step electronic expansion valve (EXV), to operate within the full range from full load to the lowest loading capacity for the chiller. Fixed orifice metering devices or float controls using hot gas bypass are not acceptable. The EXV liquid line shall have a sight glass with moisture indicator and temperature sensor connected to the control system for validation of sub-cooling.

B. Condenser shall be equipped with a mechanical float for electronic actuation of the EXV. Design shall provide a positive liquid seal to ensure effective cooling of the compressor.

C. Condenser shall be provided with a capacitive type liquid level transducer with a resolution of not less than 1024 discrete steps. The transducer shall be wired to the chiller control system. Condenser liquid level measurement shall be used in electronic expansion valve control algorithm, with a minimum level set point to ensure adequate liquid seal is maintained in the condenser, in order to provide compressor motor cooling during operation. Condenser liquid level shall be clearly displayed on a graphical operator interface in a minimum of two screens. Chillers without direct level measurement are prohibited due to possible over heating damage that may occur in compressors when liquid seal is lost. The liquid level transducer shall operate with a 0-10 volt output. To facilitate ease of maintenance, the use of 4-20mA sensors shall not be accepted.

D. Chiller shall be equipped with a redundant superheat control on the inlet of the compressor to control the EXV in the event of a failure of the primary level sensing device.

2.9 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000 VA

C. Terminal blocks with numbered wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

2.10 CHILLER CONTROLS

A. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

B. The controller fitted to the oil-free centrifugal chiller package shall be an embedded real- time microprocessor device that utilizes control software written specifically for chiller applications. User operation shall be accomplished using a panel mounted color touch-screen interface. The status of the compressors and all system parameters including compressor alarms and temperature trends shall be viewable.

C. Multiple compressors staging algorithm shall operate at the optimized power curves of each compressor simultaneously, and shall reset automatically every second during operation. Compressor staging methods that operate using simple incremental percent of demand shall not be accepted.

D. Chiller control software shall employ an active fault avoidance algorithm to reduce chiller capacity and/or power level in the case of the chiller approaching within 10% of any trip limit value such as suction pressure, discharge pressure, chiller amp limit, leaving chilled water temperature limit, etc..

E. Controller features must include the following:
   1. 10 inch, 65,000 colors touch panel operator interface.
   2. Chiller documentation shall be viewable via touch panel in pdf format.
   3. Operator interface shall be capable of connecting directly to compressors via serial communication protocol, and displaying compressor information using Turbocor compressor monitoring / commissioning software.
   4. The chiller control panel shall contain a minimum of three processors, all control functionality shall be carried out on a dedicated real time processor, and data shall be served to a remote graphical user interface via an open Ethernet protocol. Proprietary protocols between any pc based and micro based processor are strictly prohibited.
   5. Chiller controls shall be BacNet capable via MSTP or IP. Complete configuration of native BAS communications via Modbus RTU, Modbus TCP/IP, BacNet MSTP and BacNet IP shall be made via standard chiller controller graphical user interface.
   6. Chiller control shall be capable of controlling more than 2 (up to eight) Turbocor compressors on up to eight individual refrigerant circuits serving the same chilled water stream.
   7. Real time chiller control processor shall be capable of e-mailing a predefined list of recipients, should a fault occur. E-mail shall include details of fault, possible reason for fault, attachment of a monthly data log of 195 or more compressor and chiller variables at a minimum of 30 second intervals, and indication of fault severity.
   8. Ability to place all outputs in a manual state (hand, off, auto) via graphical user interface.
   9. Alarm screen shall be capable of filtering faults into specific categories such as compressor, chiller and system faults in order to provide rapid diagnosis, and separation of failure modes.
   10. Multiple compressor staging algorithm shall operate at the optimized power curves of each compressor simultaneously, and shall reset automatically every second during operation. Compressor staging methods that operate using simple incremental percent of demand shall not be accepted.
   11. Continuous data logging for operational trending and bin analysis shall be exportable to “CSV” format.

12. Built-in stepper motor controls for EXVs.
13. Controls lockup protection.
14. Three levels of alarm safety for minimum chiller down time.
15. Chiller control software shall employ an active fault avoidance algorithm to reduce chiller capacity and / or power level in the case of the chiller approaching within 10% of any trip limit value such as suction pressure, discharge pressure, chiller amp limit, leaving chilled water temperature limit, etc
16. Real time data trending viewable via touch panel.
17. Controls shall identify within 60 seconds, a compressor that is not starting or ramping-up properly. Upon this identification, the compressor shall be disabled, the remaining compressors shall be operated in an optimized manner, and an alarm shall be sent to alert the operator.

F. Enclosure: Unit mounted, NEMA 250 Type 1 hinged enclosure, factory wired with a single-point, field-power connection and a separate control circuit.

G. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

1. Date and time.
2. Operating or alarm status.
3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.
6. Operating hours.
7. Number of chiller starts.
8. Outdoor-air temperature or space temperature if required for chilled-water reset.
9. Entering- and leaving-fluid temperatures of evaporator and condenser.
10. Difference in fluid temperatures of evaporator and condenser.
11. Fluid flow of evaporator
12. Refrigerant pressures in evaporator and condenser.
13. Refrigerant saturation temperature in evaporator and condenser
14. Compressor refrigerant suction and discharge temperature.
15. Phase current.
16. Percent of motor rated load amperage.
17. Phase voltage.
18. Demand power (kilowatts).
19. Energy use (kilowatt-hours).

H. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return water temperature.
3. Current limit and demand limit.
4. External chiller emergency stop.

I. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

1. Low evaporator pressure. High condenser pressure.
2. Low evaporator fluid temperature.
3. Low oil differential pressure.
4. High compressor-discharge temperature.

5. Loss of evaporator fluid flow.
6. Motor overcurrent.
7. Motor overvoltage.
8. Motor undervoltage.
9. Motor phase reversal.
10. Motor phase failure.
11. Sensor- or detection-circuit fault.
12. Processor communication loss.
13. Motor controller fault.
14. Extended compressor surge.

J. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

K. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

L. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

M. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer or notebook computer.

N. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

2.11 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
1. Paint surfaces that are to be insulated before applying the insulation.
2. Paint installed insulation to match adjacent uninsulated surfaces.

B. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

2.12 ACCESSORIES

A. Flow Switches:

1. Chiller manufacturer shall furnish a switch for each evaporator and verify field-mounting location before installation.

2. Pressure Differential Switches:

a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
c. Set Point: Screw type, field adjustable.
d. Electrical Connections: Internally mounted screw-type terminal blocks.
e. Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

2.13 SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

1. Test the following conditions:

    a. Design conditions indicated.
    b. Reduction in capacity from design to minimum load in steps of 100%, 75%, 50% and 25% with condenser fluid at design conditions.

2. Allow owners representative access to place where chillers are being tested. Notify 10 days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2 CHILLER INSTALLATION

A. Install chillers on support structure indicated. Install per manufacturer’s IOM documentation, shop drawings, and submittal documents.

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Arrange piping to enable dismantling and permit head removal for tube cleaning

D. Charge chiller with refrigerant if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

3.3 CONNECTIONS

A. Install piping adjacent to chiller to allow service and maintenance.

B. Evaporator Fluid Connections: Connect to evaporator outlet with shutoff valve, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge and drain connection with valve. Make connections to chiller with a mechanical coupling.

C. Refrigerant Pressure Relief Device Connections: Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

D. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Factory Start-Up Services: Provide factory supervised start-up on-site for a minimum of two working days and ensure proper operation of the equipment. During the period of start-up, the

factory authorized technician shall instruct the owner's representative in proper care and operation of the equipment.

1. Provide installation and startup checks according to manufacturer's instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gauges are installed.
5. Operate chiller for run-in period.
6. Verify that refrigerant pressure relief device is vented outside.
7. Verify and record performance of fluid flow and low-temperature interlocks.
8. Verify and record performance of chiller pfindorotection devices.
9. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

C. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

D. Prepare test and inspection startup reports.

3.5 DEMONSTRATION

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

END OF SECTION 236416

SECTION 237413 – ROOFTOP AIR HANDLING UNITS WITHOUT ENERGY RECOVERY

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes central station air-handling units (rooftop units) with the following components and accessories:
1. Supply and return fans.
2. Filtration.
3. Steam coils.
4. Direct expansion: RTU-SHS-4.
5. Economizer outdoor- and return-air damper section.
6. Roof curbs.

1.2 DEFINITIONS

A. DDC: Direct-digital control.

B. RTU: Rooftop unit. As used in this Section, this abbreviation means outdoor, central-station air-handling units.

C. 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.

1.3 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.
1. Wiring Diagrams: Power, signal, and control wiring.

1.4 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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.6 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. Filters: Two sets of filters for each unit.

1.7 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 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.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within one year.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The following manufacturers are approved for use. No substitutions will be permitted.
   1. Daikin
   2. AAON
   3. Trane
   4. Carrier Company
   5. Approved equal.

2.2 GENERAL DESCRIPTION

A. Configuration: Fabricate as detailed on prints.

B. Performance: Conform to AHRI 410 and 430 Standards. See schedules on prints.

C. Acoustics: Sound power levels (dB) for the unit shall not exceed the specified levels shown on the unit schedule. The manufacturer shall provide the necessary sound treatment to meet these levels if required.

2.3 UNIT CONSTRUCTION

A. Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.

B. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.
   1. The outer panel shall be constructed of G60 painted galvanized steel.
   2. The inner liner shall be constructed of G90 galvanized steel.
   3. The floor plate shall be constructed as specified for the inner liner.
   4. Unit will be furnished with solid inner liners.

C. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.

D. The casing leakage rate shall not exceed .5 cfm per square foot of cabinet area at 5 inches of positive static pressure or 6 inches of negative static pressure (.0025 m3/s per square meter of cabinet area at 1.24 kPa static pressure).

E. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.

F. Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.

G. Provide cross broke roofcap system to divert water from the top surface of the air handler. The rain shed roofcap shall have 2”standing seams covered with splice cap channels to seal top seam. Splice cap shall break down over sides of standing seam to protect the ends of the seam.

H. The unit shall have a 6-inch curb ready base for structural rigidity and condensate trapping. The curb-ready base shall be designed with sloped drip pans located under all unit sections except duct openings and shall be supported by frame member.

I. Roof curb kit of 18-inch height shall provide support for the air handler on the building roof and provide a weather protected area for terminating and securing the roof membrane. The roof curb kit shall be manufactured by the air handler unit manufacturer.

2.4 FAN ASSEMBLIES

A. Acceptable fan assembly shall be a single width, single inlet, class II, direct-drive type plenum fan dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes. Provide access to motor and fan assembly through hinged access door.

B. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry.

2.5 BEARINGS, SHAFTS, AND DRIVES

A. Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be provided on the motor with the fan wheel mounted directly on the motor shaft, AMCA arrangement 4.

B. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

C. The fan wheel shall be direct coupled to the motor shaft. The wheel width shall be determined by motor speed and fan performance characteristics.

2.6 ELECTRICAL

A. The air handler(s) shall be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.

B. Fan motors shall be manufacturer provided and installed, Open Drip Proof, premium efficiency (meets or exceeds EPAct requirements), 3500 RPM, single speed, 200V / 60HZ / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.

C. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.

D. Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

E. Air handler manufacturer shall provide, mount and wire ABB variable speed drive with electrical characteristics such as indicated on project schedule and shown on manufacturer's data sheets.

2.7 COILS

A. Steam coils:
   1. Coils shall be designed to withstand 50 psi maximum operating pressures and a maximum steam temperature of 300°F for standard duty copper tube and header coils. Mid pressure coils (50-200 psi) shall be designed with copper tubes and cupronickel headers to withstand 400 degrees. Optional high-pressure construction will include cupronickel tubes and headers to increase maximum operating pressure to 350 psi and maximum operating temperature to 450 degrees. Maximum temperatures and pressure can be obtained utilizing an all carbon steel or stainless-steel construction.
   2. Coils shall be of plate fin type construction providing uniform support for all coil tubes. Stainless steel fins shall be constructed of 304 & 316 stainless. Carbon steel fins shall be constructed of ASTM A109-83. Coils are to be manufactured with die-formed aluminum, copper, stainless steel or carbon steel fins with self-spacing collars, which completely cover the entire tube surface. The fin thickness shall be 0.0075 +/- 5% unless otherwise specified. Manufacturer must be capable of providing self-spacing die-formed fins 4 through 14 fins/inch with a tolerance of +/- 4%.

B. Units scheduled with Direct expansion:
   1. refrigerant cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 3” beyond unit casing for ease of installation. Coil connections must be factory sealed with grommets on interior and

exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

2. Sweat type copper suction headers shall be provided.
3. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
4. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins on 1 1/2-inch centers, brazed at joints.
5. Sweat type copper suction connections located at the bottom of the suction headers for gravity oil drainage. Coils shall be uniformly circuited in a counterflow manner for either single circuit, row, face, interlaced, or interlaced face split capacity reduction as shown on unit schedule. Pressure type liquid distributors used. Coils shall be tested with 315 pounds air pressure under warm water, and suitable for 250 psig working pressure.
6. Coil casing shall be a formed channel frame of galvanized steel.

2.8 FILTERS

A. Furnish flat panel filter section with 2-inch pleated MERV 8 filter with microbial resistant Intersept coating. Provide side loading and removal of filters.

B. Filter media shall be UL 900 listed, Class I or Class II.

C. Filter Magnehelic gauge(s) shall be furnished and mounted by equipment manufacturer.

2.9 ADDITIONAL SECTIONS

A. Plenum section shall be provided and properly sized for inlet and/or discharge air flow (between 600 and 1500 feet per minute). The plenum shall provide single or multiple openings as shown on drawings and project schedule.

B. Economizer section shall be provided with right side outside air opening and end return air opening and left side exhaust air opening with or without parallel low leak airfoil damper blades. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Linkage and ABS plastic end caps shall be provided when return and outside air dampers sized for full airflow. Return and outside air dampers of different sizes or very large dampers and exhaust dampers must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 2 inches static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.

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. Roof Curb: Coordinate installation of roof curb with General Contractor.

B. Unit Support: Install unit level on curb.

3.3 CONNECTIONS

A. 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. Connect supply ducts to RTUs with flexible duct connectors.
   3. Install return-air duct continuously through roof structure.

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. Verify that labels are clearly visible.

3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Remove packing from vibration isolators.
7. Verify lubrication on fan and motor bearings.
8. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
9. 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.
10. Inspect and record performance of interlocks and protective devices; verify sequences.
11. Operate unit for an initial period as recommended or required by manufacturer.
12. Calibrate thermostats.
13. Adjust and inspect high-temperature limits.
14. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
15. Inspect controls for correct sequencing of heating, mixing dampers and emergency shutdown.
16. 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.
17. 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. Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237413

SECTION 238216 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydronic heating air coils.

1.2 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 air coil.
   2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the project requirements provide coils by one of the following manufacturers.
   1. Daikin Applied.
   2. Super Radiator.
   3. Trane.
   4. Carrier.
   5. York.

2.3 GENERAL DESCRIPTION

A. Furnish as shown on plans and as described in the specification, Daikin Applied Water Heating Coils.

B. Coils to have extended surface, staggered tube, and plate fin design.

2.4 HEADERS

A. Made of seamless copper tubing to assure compatibility with primary surface.

B. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.

C. Vent and drain plugs shall be provided on the coil header.

2.5 CONNECTIONS

A. Coil connection should be compatible with the piping to the coil to minimize chance of "galvanic action/electrolysis".

B. Connections shall be a diameter adequate for specified gpm flow.
   1. The connections are located to permit right hand mounting of the coil and assure equal pressure through all the circuits.

C. Connection and material type.
   1. Connection material to be carbon steel pipe. Connection type to be threaded.

D. Coils are circuited to provide maximum mean effective temperature difference for heat transfer rates.

E. Coils, greater than 2 rows, must be arranged for counter flow.

2.6 TESTING AND PRESSURE RATINGS

A. Completed coils are tested at a minimum of 315 PSIG air pressure while submerged in warm water.

B. Hydronic tests alone are not acceptable.

C. Standard coil construction is rated for 250 PSIG working pressure at 300 degrees F.

2.7 CAPACITY

A. Coil capacity shall be as outline on the project schedule and confirmed with computer generated output.

B. Application.
   1. Heating.

C. Fluid Type.
   1. Water.

2.8 PRIMARY SURFACE

A. Tubes to be 5/8” O.D., staggered in direction of airflow, and must be on 1 ½” tube centers.

B. Wall thickness to be .020” nominal copper and water pressure drop of coil selection adjusted to wall thickness specified.

C. Tubes to be mechanically expanded in to fin collars to provide a continuous primary to secondary compression bond over entire coil length, assuring maximum heat transfer.

D. Coil Tube Type.
   1. Standard smooth bore.

2.9 SECONDARY SURFACE

A. Plate style fins shall be corrugated for high capacity and structural strength.
   1. Fin thickness shall be .0075" aluminum.

B. The fins to have collars to determine fin spacing per inch and support the heat transfer bond to primary surface. Tubing should not be visible between the fins.
   1. Fin Style to be a New Ripple fin type.

2.10 COIL TYPE & SERPENTINE

A. 5WH - Half Serpentine.

B. Coils available from 12" to 54" fin height on 1.5" tube centers and on 3" increments.

C. All water heating coils with standard .020" nominal copper tubing available from 12” to 216” fin length in two decimal point increments. For other tube material types the maximum tube length is 180".

2.11 CASINGS

A. Casing Style
   1. Contractor Coil with flanged casing.

B. Casing Material.
   1. Galvanized Steel.

2.12 PROTECTIVE COATINGS

A. Daikin’s electro-fin coating where scheduled.

2.13 PACKAGING

A. Coil(s) to be fully crated in a wood enclosure with protective cardboard covering the finned area.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

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

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Straighten bent fins on air coils.

D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

END OF SECTION 23 8216

SECTION 238220 – VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.1 System Description

A. Provide variable refrigerant flow heat pump system with integral controls. Each indoor unit shall be independently controlled.

B. Provide factory startup and commissioning by manufacturer's representative.

1.2 PIPING

A. Piping to multiple indoor units requires additional piping components. The VRF equipment manufacturer's Y-joint fittings must be used to branch the main refrigerant lines.

B. The VRF equipment manufacturer's Tee fittings must be used to connect outdoor units when multiple module systems are being installed (systems with more than one outdoor unit).

1.3 Quality Assurance

A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

D. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit. Additional refrigerant is required based on diameters and lengths of system liquid refrigerant lines and indoor equipment model and quantity.

E. The installing contractor must have attended Samsung DVM S installation training prior to installing the system.

F. Service and installation manuals must be readily available on the manufacturer's website without entering a username and password.

G. Provide 10-year parts, 10-year compressor and 1-year limited labor warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Subject to compliance with the project requirements, provide equipment by one of the following manufacturers:
   1. Samsung (Basis of Design), no substitutions.

2.2 HEAT PUMP OUTDOOR UNIT – LOW AMBIENT

A. General:
   1. The heat pump outdoor unit shall be specifically used with SAMSUNG DVM S Max Heat, heat pump components. The SAMSUNG DVM S Max Heat HP outdoor unit shall consist of the AM***KXVT*H/AA outdoor unit, indoor units (AM****N**C*/AA), and SAMSUNG DVM S NASA Control Network Solution (Control systems). The

AM***KXVT*H/AA outdoor units shall be equipped with multiple circuit boards that interface to the SAMSUNG DVM S NASA Control Network Solution (Control systems) and shall perform all functions necessary for operation. The outdoor unit shall have a powder coated finish. The outdoor unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.

2. The heat pump outdoor unit shall be capable of operating in heating mode between -13°F ~ 75°F ambient temperatures.
3. The heat pump outdoor unit shall be able to provide 100% heating capacity at -13°F outside ambient temperatures (no degradation of capacity down to -13°F due to outside ambient temperature).
4. The heat pump outdoor unit shall be capable of operating in cooling mode between 23°F ~ 120°F outside ambient temperatures.
5. The heat pump outdoor unit shall be capable of operating in cooling mode below 23°F down to 5°F outside ambient temperature with the addition of LACH side and rear guards.
6. The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of outdoor rated capacity.
7. The heat pump system compressors shall be SAMSUNG, asymmetric, hermetically sealed, inverter driven, direct flash injected, DC scroll type. No fixed capacity compressors shall be present in the refrigerant system.
8. The heat pump system shall have the ability to change operation mode without turning off the compressors allowing for constant heating and cooling operation
9. Outdoor unit (individual modules) shall have a sound pressure rating no higher than 61 dB (A).
10. The VRF system shall allow connection of up to three (3) low ambient heating outdoor unit modules to a single system (three module system).
11. The outdoor unit shall have advanced oil recovery cycle logic operation that shall not interrupt heating or cooling operation. The oil recovery cycle duration shall not exceed three (3) minutes while in cooling mode or six (6) minutes while in heating mode. While in heat mode, any defrost cycle lasting over three (3) minutes shall be considered an oil recovery cycle.
12. Advanced intelligent defrost logic to significantly reduce defrost cycle frequency by monitoring air resistance across the condenser coil during heating operation to determine defrost operation initiation to prevent unnecessary defrost cycles.
13. Both refrigerant lines from the outdoor unit shall be insulated.
14. The heat pump outdoor unit shall have an accumulator with ARV (accumulator return valve) control.
15. The heat pump outdoor unit shall have a high-pressure safety switch, high voltage fuses, over-current protection, phase detection protection, thermal fan protection, low pressure protection, compressor overcurrent protection, fan motor voltage protection, current transformer(s), crank case heaters, and intelligent logic to ensure proper operation within unit design limitations and operational parameters.
16. The Inverter compressor driver PCB(s) shall cooled with liquid refrigerant circuit(s) to operate at optimal temperatures and to prevent failure due to overheating. No compressor inverter PCB's will be cooled by air over heat sink. Cooling inverter components without air-cooling fins prevents failure due to environmental contaminants.
17. The heat pump outdoor unit shall have the ability to operate with a maximum height difference of 361 feet with the condensing unit installed higher than the indoor units (with modified piping and PDM kit when greater than 164 feet). The heat pump outdoor unit shall have the ability to operate with a maximum height difference of 361 feet with the condensing unit installed lower than the indoor units (conditions apply when over 131, see

graph below). Maximum 3,280 feet total refrigerant tubing length. The greatest length is not to exceed 656 (722 equivalent) feet between outdoor unit and the farthest indoor unit.

18. The heat pump system shall allow adjustment of target evaporator coil temperatures in cooling mode and target heating discharge pressures depending on project conditions for heating and cooling calibration thus saving energy.
19. The heat pump outdoor unit shall have a high efficiency, individual oil separators for each compressor plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
20. The heat pump outdoor unit shall have a flat-plate type subcooler to sub cool liquid refrigerant further to increase capacity and performance with long pipe lengths and to decrease refrigerant sounds at indoor equipment.
21. The compressors shall have flash injection capability to increase performance in heating mode. This will be automatically enabled by the outdoor unit(s) by forcing saturated refrigerant liquid and flash mixture directly into the scroll compression cycle increasing mass flow and overall system capacity. Compressors without flash or flash injection shall not be present in the VRF heat pump system.
22. The heat pump system shall have optional snow blowing settings to prevent snow accumulation on top of unit. Optional outdoor unit hoods are also available to protect the top of the outdoor unit.
23. The heat pump system shall have optional night quite modes to reduce unit sound in evenings (4 levels). Night quite modes can be activated automatically or manually with MIM-B14 external contact control interface module.
24. The heat pump system shall have current control to limit current (50% - 100% of design current) adjustable at outdoor unit, or central web accessible control devices: MIM-D00AN, MIM-D01AUN, MIM-B17N, MIM-B17BUN, MIM-B18N and MIM-B18BUN.
25. The heat pump outdoor unit shall have a removable EEPROM at the main PCB to store all unit data. All data on the outdoor unit EEPROM shall be viewable from the manufacturer provided service software. The outdoor unit main EEPROM shall be removable allowing replacement of outdoor unit PCB without losing digital, field programmed data. The outdoor unit removable EEPROM shall store the following unit data: unit model number, unit serial number, unit main PCB firmware and MICOM version, sub-PCB firmware and MICOM version, fan PCB firmware and MICOM version, inverter PCB 1 and inverter PCB 2 firmware and MICOM version, auto-trial commissioning startup data, the last 30 minutes of operation data, and field programmed unit name/tag viewable on controls and service software.
26. The heat pump outdoor unit shall have the ability to discharge inverter PCB capacitor voltage using service buttons on the outdoor unit main PCB. The capacitor stored-voltage discharge feature shall allow safe inverter PCB replacement.
27. The heat pump outdoor unit shall have outdoor unit pump-down operation capability allowing storage of refrigerant while opening sealed refrigerant pipe system outside of outdoor unit chassis while performing service. The outdoor unit refrigerant storage shall be greater than the supplied factory R-410A charge.
28. The heat pump outdoor unit shall have individual outdoor module pump-out operation capability allowing the majority of refrigerant in an outdoor unit to be pumped out. The pump-out feature shall allow service of sealed refrigerant system within an outdoor unit chassis.
29. The heat pump outdoor unit shall allow temporary disabling of individual compressors to allow system operation at reduced capacity after a compressor or compressor component related issue (when more than one compressor is present in system). Disabling of a compressor shall temporarily remove error codes and allow system operation.

30. The heat recovery outdoor unit shall have capability to reduce compressor Hz (heating capacity) further when average indoor unit ((set temperature – room temperature) < 3.6º F) while operating in heating mode, thus saving energy.
31. The heat recovery outdoor unit shall have capability to reduce compressor Hz (cooling capacity) when average indoor unit ((room temperature – set temperature) < 3.6º F) while operating in cooling mode, thus saving energy.
32. The heat pump outdoor unit compressors shall have a soft-start function to reduce electricity demand during system start and to increase compressor reliability.
33. In the event of system error due to outdoor unit failure, the heat pump outdoor unit shall display codes that specify a precise error and which outdoor unit PCB is the cause (main PCB, HUB PCB, IPM 1, IPM 2, fan PCB).
34. The heat pump system shall support system auto-addressing allowing system commissioning without manually configuring indoor unit addresses.
35. Unit Cabinet:
    a. The chassis shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel.
36. General:
    a. All fan motors shall be variable speed BLDC type.
    b. All fan motors shall have inherent protection, thermal protection, and have permanently lubricated bearings, and be completely variable speed.
    c. All fan motors shall be mounted for quiet operation.
    d. All fans shall be provided with a raised guard to prevent contact with moving parts.
    e. The outdoor unit shall have vertical discharge airflow.
    f. The heat pump outdoor units shall have the capability for ducting of discharge air up to 0.32” WC static pressure with factory provided dimensional design drawings. The heat recovery outdoor units shall not require any field installed components or component modification to allow ducting of discharge air.
37. Refrigerant:
    a. R410A refrigerant shall be required for the heat pump system.
    b. Additional refrigerant is required. Amount is based on installed refrigerant pipe diameters and lengths and indoor equipment model number and quantity.
38. Coil:
    a. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
    b. The Heat Pump condensing unit salt spray test method: KS D 9502 (ASTM B117 equivalent) - the heat exchanger showed no unusual rust development to 2000 hours.
    c. The coil shall be protected with an integral metal guard.
    d. Refrigerant flow from the outdoor unit shall be controlled by means of capacity modulation capable vapor injection scroll compressor.
39. Compressor:
    a. All compressors shall be modulation capable, direct vapor injected, DC inverter, scroll type.
40. General:
    a. Crankcase heaters shall be factory mounted on the compressors.
    b. The outdoor unit compressor shall have a variable modulation technology to modulate capacity. System capacity shall be completely variable down to 7,513 Btu/h.
    c. The outdoor unit compressor shall have vapor injection technology (excluding AM216KXVGJH/AA) which can increase the mass flow rate of refrigerant and

offset refrigerant condensing temperatures resulting in a capacity and performance improvement in heating mode.

d. The AM216KXVGJH/AA outdoor unit compressors shall have flash injection technology which can increase the mass flow rate of refrigerant and offset refrigerant condensing temperatures resulting in a capacity and performance improvement in heating mode.

e. The compressor(s) will be equipped with an internal thermal overload.

f. The compressor(s) shall be mounted to avoid the transmission of vibration.

41. Electrical:

a. The outdoor unit electrical power shall be 208/230 volts, 3 phase, 60 hertz or 460 Volts, 3 phase, 60 hertz.

b. The 208/230 VAC unit shall be capable of satisfactory operation within voltage limitations of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

c. The outdoor unit shall be controlled by integral microprocessors.

d. The control circuit between the indoor units and the outdoor unit shall be 0.5VDC - 7VDC completed using stranded, annealed copper conductor, 16 AWG, shielded, two-core cable to provide total integration of the system.

42. Outdoor Unit Accessories:

a. Wind/hail guards shall be available for installation on the outdoor units.

b. Side and rear wind/hail guards are noted below (one per module).

1) Low ambient cooling accessories are available as noted below to provide 100% cooling operation down to -13°F for both heat pump and heat recovery systems.

2) Advanced logic control will be done to fine tune louver position based on outdoor unit high pressure, outdoor ambient temperature, outdoor unit compressor compression ratio, mode, and other outdoor unit points.

2.3 AM0**KN4DCH/AA (360 CASSETTE) INDOOR UNIT

A. General:

The 360 cassette style indoor unit shall recess into the ceiling with a ceiling grille (ordered separately, part number: PC4NUDMAN (“ceiling type”, square, white), PC4NBDMAN (“ceiling type”, square, white), PC4NUNMAN (“open type”, circle, white), and PC4NBNMAN (“open type, circle, white). The 360 Cassette indoor unit shall be compatible with DVM S HR (Heat Recovery) outdoor units and MCU (Mode Control Unit, MCU-S*NE**N) or DVM S HP (Heat Pump) outdoor units. The 360 Cassette indoor unit shall support individual control using SAMSUNG DVM S NASA Control Network Solution (Control systems). The 360 cassette shall support individual control using SAMSUNG NASA Control Network Solution (Control systems). Indoor model numbers shall be: AM009KN4DCH/AA, AM012KN4DCH/AA, AM018KN4DCH/AA, AM024KN4DCH/AA, AM030KN4DCH/AA, AM036KN4DCH/AA, and AM048KN4DCH/AA.

Each system shall perform in accordance to the ratings shown in the table below. Performance shall be based on nominal cooling conditions of 80°F DB, 67°F WB for the indoor unit and 95°F DB for the heat pump/heat recovery outdoor unit and nominal heating conditions of 70°F DB for the indoor unit and 47°F DB, 43°F WB for the heat pump/heat recovery outdoor unit.

System Model Number	***Btu/h Cooling****	***BTU/h Heating****
AM009KN4DCH/AA	9,000	10,000
AM012KN4DCH/AA	12,000	13,500
AM018KN4DCH/AA	18,000	20,000
AM024KN4DCH/AA	24,000	27,000
AM030KN4DCH/AA	30,000	34,000
AM036KN4DCH/AA	36,000	40,000
AM048KN4DCH/AA	48,000	54,000

**Nominal capacity*

1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board, condensate pump, and fan motor.

2. The indoor unit shall include an internal condensate pump with check-valve as standard with a maximum vertical lift of 29 inches.

3. The indoor unit shall have an integral condensate float switch to disable the unit in the event of condensate overflow.

4. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function.

5. The indoor unit refrigerant pipes shall be charged with dehydrated air (Nitrogen gas) before shipment from the factory.

6. The indoor unit shall be a round ceiling cassette with 360°, even air distribution

7. The indoor units shall have a removable EEPROM that stores system programming information, unit name, and other data.

8. All indoor unit addressing and option settings shall be done digitally; the indoor unit does not contain rotary dials or setting switches.

9. The indoor unit shall not have air louvers or blades allowing full airflow without restriction. Air direction control shall be achieved by creating a low pressure area near air outlet causing discharge air to change direction angle.

A. Unit Cabinet

1. The cabinet shall be space-saving ceiling-recessed cassette.

2. Construction shall be HIPS chassis with a galvanized steel frame and fascia panel certified to UL94 V0.

3. Each corner portion of the panel cabinet is detachable, which gives easy access to adjust the

height.

4. The cabinet shall have provisions for a field installed, filtered, outside air intake. A booster fan is necessary. A 12V DC relay terminal is available to control a booster fan (with separate PCB connector).

5. The "ceiling type" fascia panel model PC4NUDMAN shall be square in shape, **white**, with a circular air outlet opening. This panel is designed for use in applications where the indoor unit chassis is recessed in the ceiling with a finished ceiling textile.

6. The "ceiling type" fascia panel model PC4NBDMAN shall be square in shape, **white**, with a circular air outlet opening. This panel is designed for use in applications where the indoor unit chassis is recessed in the ceiling with a finished ceiling textile.

7. The "open type" fascia panel model PC4NUNMAN shall be, **white**, circular in shape with a circular air outlet opening. This panel is designed for use in applications where the indoor unit chassis is exposed.

8. The "open type" fascia panel model PC4NBNMAN shall be, **white**, circular in shape with a circular air outlet opening. This panel is designed for use in applications where the indoor unit chassis is exposed.

9. The fascia panel shall have LED indicator lights and an infrared receiver.

B. Fan

1. The indoor fan assembly shall be a turbo fan, direct driven by a single motor.

2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.

3. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.

Model Number	Fan Speed Setting
AM009KN4DCH/AA AM012KN4DCH/AA AM018KN4DCH/AA AM024KN4DCH/AA AM030KN4DCH/AA AM036KN4DCH/AA AM042KN4DCH/AA AM048KN4DCH/AA	(UL) - Low – Mid – High - Turbo

4. Fixed or auto-swing air direction shall be possible with wireless, touch, or premium wired controller (10° ~ 60° angle)

5. Independent air distribution control is possible with wireless or premium wired controller (three directions, 10° ~ 60° angle).

6. Airflow direction shall be accomplished without any air blades/louvers to remove air flow restriction in the air outlet path. Instead, the cassette indoor unit shall use three (3) internal booster fans to create an area of low pressure outside of the air outlet opening causing the air

to change direction. Changing air direction in this manner (Coanda effect) is superior to traditional air louvers/blades on standard 4-way cassette indoor units.

C. Filter

1. Return air shall be filtered by means of a long-life washable permanent, electro-static filter included with fascia panel.

D. Coil

1. The indoor coil shall be of nonferrous construction with slit fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan with drain pump shall be provided under the coil.
6. The coil fins are coated with hydrophilic paints.
7. The condensate lift mechanism shall be able to raise drain water 29 inches above the condensate pan with built in check valve and float switch.
8. Both refrigerant lines to the 360 cassette indoor units shall be insulated.

E. Electrical

1. The unit electrical power shall be 208/230 volts, 1-phase, and 60 hertz supplied from the condensing unit.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
3. The indoor unit PCB contains a time-lag fuse.
4. The control circuit between the indoor units, and the outdoor unit shall be 0.5VDC - 7VDC completed using stranded, annealed copper conductor, two-core, 16 AWG, shielded cable to provide total integration of the system. The outdoor unit shall supply power to indoor unit via 14 AWG X 3 power wire
5. The indoor unit shall have a thermal fuse under high-voltage terminal block to disable unit in the event of overheating due to electrical malfunction/poor connection.

PART 3 - CONTROLS

3.1 OVERVIEW

A. General:
1. Provide BACnet gateway.
2. Provide controls for complete standalone operation. Integrate with building management system to provide BMS control.

3. The DVM Controls Network Solution shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet® and LonWorks®.

B. Electrical Characteristics:
1. General:
   a. The DVM S Controls Solution shall operate at 12V DC (excluding MCM-A202DN ON/OFF Controller). Controller power and communications shall be via a common communications bus.
2. Wiring:
   a. Main system control wiring (COM1, F1/F2) shall be installed in a system daisy chain configuration from the indoor equipment to MAIN outdoor unit. This cable shall be 16 AWG X 2, shielded cable.
   b. Zone control wiring (COM2, F3/F4) to wired remote controllers (MWR-****N) shall be run from the indoor unit terminal block to the controller associated with that unit. This cable shall be 16 AWG X 2, shielded cable.
   c. Control wiring for system controllers and centralized controllers (upper level) shall be installed in a daisy chain configuration from water-source unit to water-source unit (R1/R2), to system controllers.
   d. Communication wire connection (OF1/OF2) between water-source unit modules (systems with 2 or more modules) must be connected from the MAIN unit to SUB1 and SUB2 (where applicable). This wire shall be 2-conductor, 16 AWG X 2, shielded cable.
   e. MST-P3P (S-Net3 software) shall be capable of being networked with up to 16: MIM-D00AN (DMS2), MIM-D01AUN (DMS2.5), MIM-B17N (BACnet gateway 2.0), MIM-B17BUN (BACnet gateway 2.5), MIM-B18 (LonWorks gateway2.0), and/or MIM-B18BUN (Lon Works gateway 2.5) system controllers for web/LAN based control for consolidated control.
3. Wiring type:
   a. COM1 and COM2 control wiring shall be 2-conductor, 16 AWG X 2, shielded cable.
   b. Network wiring shall be CAT-5e with RJ-45 connection.

3.2 DVM CONTROL NETWORK SOLUTION

1. General:
2. The SAMSUNG DVM S NASA Control Network Solution consists of remote controllers, system controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The SAMSUNG DVM S NASA Control Network Solution shall support operation monitoring, scheduling, error monitor, power distribution, personal browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces.
3. MULTI-FUNCTION CONTROLLER – PREMIUM INDIVIDUAL WIRED CONTROLLER (MWR-WE11N, MWR-WE13N)
   a. Connection:
      1) The wired controller shall control up to 16 SAMSUNG indoor units or SAMSUNG ERV's (defined and controlled as one group).
   b. Dimensions:
      1) The wired controller shall be approximately 4 5/8" x 4 7/8" in size and white in color

4. The wired controller shall control indoor units and SAMSUNG ERV as follows:
   a. Air handler and ERV unified controller (can only control SAMSUNG ERV's)
   b. Air handler operation ON/OFF
   c. Air handler operation mode, set temperature, air flow direction, fan speed, individual louver control (with supported indoor units), discharge air temperature (with supported indoor units)
   d. Quiet and sleep modes
   e. Error display
   f. Filter replacement alarm display and reset
   g. Single indoor unit control or multiple unit control (maximum 16 units)
   h. Energy saving operation:
   i. Upper/lower temperature setting
   j. Automatic operation stop function
   k. Energy saving operation mode
   l. Weekly operating schedule setting:
   m. Weekly operating schedule (A/C only, ERV only, A/C + ERV)
   n. Options to set: desired A/C operation mode, setting temperature, power mode (ON/OFF), and fan speed to operate based on weekly or daily schedules
   o. Optional schedule exception day setting
5. Other wired controller features:
   a. Different button permission levels
   b. Partial button lock option (on/off, selection, temperature setting, fan speed, and schedule setting buttons can be locked individually)
   c. Backlight
   d. Daylight savings clock advance option
   e. Upper and lower temperature setting restriction
   f. Auto mode skip
   g. Heat mode skip (cooling only)
   h. Restrict wireless controller signal (optional)
   i. Louver position setting (cassette and wall units)
   j. Individual louver/blade control for 4-way and mini 4-way cassettes.
   k. Individual air direction control for 360 Cassette indoor units.
   l. Auto-off option to automatically turn the associated indoor unit(s) off after the specified time without any interaction with the wired controller.
   m. System/indoor unit function and operation indication (defrost, error, restricted controller, SPi status)
   n. Quiet Mode setting (for supported units)
   o. Service mode for connected indoor unit operation monitoring, addressing, and setup
   p. Can be used to specify "Mode Master" while connected to a single indoor unit when used with heat pump systems.
   q. Real-time clock function - current time/day display function
   r. Built-in room temperature sensor
   s. Indoor unit operation state display
   t. Service mode support (Indoor unit addressing, indoor unit cycle data monitoring, option code monitoring and setting, and option setting/monitoring).
   u. Time synchronization with central DMS2.5 central control gateways (MIM-D01AUN, MIM-B17BUN, MIM-B18BUN).
6. MWR-WE13N specific features:
   a. Wind-Free™ display and control for supported indoor unit models.

b. Motion Detection Sensor Control (On/Off, Indirect/Direct) for supported indoor unit models. Applies to optional MDS MCR-SMA, MCR-SMC, and MCR-SMD. Indirect/Direct control only applies to supported units that have MCR-SMC and MCR-SMD installed.
c. Clean and Long reach function for supported indoor unit models.

7. Specifications:
   a. Two (2) conductor connection, PLC, (F3/F4).
   b. DC 12V (power supplied by indoor unit via F3/F4 connection).
   c. RS485 communication (F3/F4).
   d. Can sense temperature via internal sensor, temperature sensor inside the air handler, or use the average temperature between controller and air handler temperature sensors.
   e. The wired controller shall have two screw terminals for wiring connections. Wire is not included with controller.
   f. 16AWG X 2 shielded cable is necessary for proper operation.
   g. The wired controller shall allow up to 328 feet of wire from the farthest connected indoor unit to the controller.

Multi-Function Controller			
Item	***Description***	***Operation***	***Display***
ON/OFF	Run and stop operation for a single group Including Samsung ERV operation	Each Group	Each Group
Operation Mode	Switches between Auto/Cool/Dry/ Fan/Heat	Each Group	Each Group
Temperature Setting	1. Sets temperature for a single group. 2. Range of temperature setting a. Auto/Cool/Dry: 65°F-86°F b. Heat: 61°F-86°F 3. Setting discharge outlet air temperature for supported indoor units.	Each Group	Each Group
Discharge Air Temperature Setting	Sets temperature for supported ducted units	Each Group	Each Group
Fan Speed Setting	1. Models with 3 air flow speed settings: High /Mid/Low/Auto 2. Wind-Free™ mode enable/disable (MWR-WE13N only) 3. Motion Detection Sensor Control 4. Clean and Long reach function for supported indoor unit models.	Each Group	Each Group
Air Flow Direction Setting	1. Air flow 2-step direction (Swing/Stop) 2. Direct setting at a specific angle. 3. Air flow operation varies depending on the model.	Each Group	Each Group

Multi-Function Controller			
Item	***Description***	***Operation***	***Display***
Weekly Schedule	1. ON/OFF/Temperature setting can be done at most 10 schedules may be set for each day. 2. Real-time clock function: current time, day display function	Each Group	Each Group
Button lock	1. Button permission level setting (On/Off / Temperature setting / Mode button / Fan speed) 2. Temperature limit setting 3. After power reset, the setting value is restored 4. Various restriction capabilities	Each Group	Each Group
Specified Function	1. Automatic stop setting (setting time range: 0-12 hours) 2. Energy saving operation mode (IDU+ERV or ERV operation only depending on outdoor temperature)	Each Group	Each Group
Service Mode	1. Viewing/Setting indoor unit option code 2. Viewing/setting indoor unit MAIN address 3. Viewing/setting indoor unit RMC address 4. Viewing indoor unit cycle data 5. Setting/Viewing temperature sensor compensation of the wired remote controller (-9°F~ +9°F) 6. Viewing RPM compensation 7. Viewing/setting EEV stop step when indoor unit is thermal-off during heating mode 8. Viewing/setting filter reminder time interval (1000 hours, 2000 hours) 9. Viewing/setting indoor unit temperature sensor compensation during Heating (+2°F or +5°F) 10. Viewing the H/W option setting 11. Viewing wired remote controller software version 12. Viewing/setting individual louver lock	Each Unit	Each Unit
Blade	Setting individual blade positions on 4-Way Cassette (AM0***N4DCH/AA)	Each Unit	Each Unit

Multi-Function Controller			
Item	***Description***	***Operation***	***Display***
Error	When an error is currently occurring in the system, the afflicted unit and the error code are displayed	Each Group	Each Group
Permit / Prohibit Local Operation	Setting/releasing of simplified locking of remote control buttons	Each Group	N/A
Quiet Mode	Select the quiet mode to lower the fan noise level.	Each Group	N/A
Room Temperature	Actual room temperature or set temperature can be displayed	Each Group	Each Group

**Some features may not be available depending on the model of connected air handler(s).*

3.3 INSTALLATION

A. Maintain manufacturer's recommended clearances.

A. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

B. Install units level and plumb.

C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

D. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

E. Outdoor Equipment Mounting: Mount or roof rails as indicated on drawings.

F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

G. Provide additional refrigerant charge as required to fill system.

H. Install fan coil units to comply with NFPA 90A

I. Suspend fan coil units from structure with elastomeric hangers.

J. Install new filters in each fan coil unit within two-weeks after Substantial Completion.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections as recommended by unit manufacturer.

B. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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

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

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform and document startup service.

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections. Provide documentation in closeout documentation.

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

B. Prepare test and inspection reports.

A. Adjust initial temperature and humidity set points.

3.7 DEMONSTRATION

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

END OF SECTION 238220

SECTION 238223 - UNIT 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 unit ventilators and accessories with the following heating and cooling features:
   1. Hydronic heating coil.
   2. Hydronic cooling coil.

1.3 ACTION SUBMITTALS

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

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. Detail anchorages and attachments to structure and to supported equipment.
   4. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which equipment will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Size and location of access panels in hard ceilings to provide access to concealed units.
   6. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   7. Perimeter moldings.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For unit ventilators 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. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

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. Unit Ventilator Filters: Furnish 2 spare filters for each filter installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of units that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Coil leak.
   2. Warranty Period: Five years from date of Substantial Completion.

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. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Corporation.
   2. McQuay International.
   3. Trane.
   4. Magic Aire.

2.3 MANUFACTURED UNITS

A. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in draw-through configuration, and hydronic cooling coil.

2.4 CABINETS

A. Insulation: Minimum 1/2-inch-thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner, formed as required by ASHRAE 62.1. Heating-only units shall also be provided with drain pans for future installation of a cooling coil.

C. Cabinet end pockets shall be a minimum of 12 inches wide to facilitate piping and service. If the standard end pocket is less than 12 inches wide an extended cabinet unit shall be provided.

D. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors.
   1. Steel components exposed to moisture shall be hot-dip galvanized after fabrication.
   2. Ceiling-mounted units:
      a. Ceiling units shall be constructed with two hinged bottom panels for ease of maintenance. Access to filters, controls and piping shall be easily available through the two bottom panels. Retainer chains shall be factory installed to prevent sudden release of bottom panels

E. Cabinet Finish: Electrostatically painted with an oven-baked thermosetting urethane powder finish, color as selected by Architect.

F. Indoor-Supply-Air Grille: Steel linear bar welded in-place as an integral part of the unit structure.

G. Return-Air Inlet: Front toe space.

H. End Panels: Matching material and finish of unit ventilator.

I. Outdoor-Air Wall Box (Floor-mounted units): Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
   1. Louver Configuration: Vertical, rain-resistant louver.
   2. Louver Material: Aluminum.
   3. Bird Screen: 1/2-inchmesh screen on interior side of louver.
   4. Decorative Grille: On outside of intake.
   5. Finish: Anodized aluminum.

J. Floor-mounted units shall have an integral pipe tunnel for convenient installation of through-piping.

2.5 COILS

A. Test and rate unit ventilator coils according to ASHRAE 33.

B. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psigand a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

2.6 INDOOR FAN

A. Motors shall be ECM.

B. Fan and Motor Board: Removable.
1. Fan: Forward curved, double width, double inlet, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls, with offset aerodynamic blades.
2. Fan Shaft and Bearings: 1-1/4” dia. hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
3. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment." Motor speed shall be controlled by factory mounted multi-tap transformer through a High-Medium-Low-Off switch. Motors shall be 115/60/1 NEMA permanent split capacitor (PSC), plug-in type designed specifically for unit ventilator operation. Motors shall be located out of the airstream and have an internal thermal overload device (auto reset). Fan motors and controls shall have each hot line protected by factory installed cartridge type fuse(s). Motors shall have sleeve type bearings and require oiling no more than once annually. Units shall have shaft bearing located out of the air stream. Bearings in the airstream are not acceptable
4. Wiring Termination: Connect motor to chassis wiring with plug connection.
5. The fan and motor assembly shall be rated at low or medium speed to meet the design criteria.
6. For Ceiling-mounted units, provide high-static fan motor.

2.7 FILTERS

A. Unit filters shall be MERV 13.

B. Filter shall be one-piece design located to provide filtration of the outdoor air/return air mixture to assure even dust loading and balanced airflow in lieu of separate filters for outdoor air and return, and shall be factory furnished initially installed in all units.

2.8 DAMPERS

A. Outside and Room Air Dampers: The room air damper shall be constructed of aluminum using metal-forming techniques to resist twisting and shall be counterbalanced against backpressure. Outdoor air damper shall be two-piece double-wall construction with 1 /2 " thick, 1.5 lbs. density fiberglass insulation encapsulated between welded 20 ga. galvanized steel blades for rigidity and to inhibit corrosion, and have additional insulation on the exterior surfaces of the damper blade and on the ends of the outdoor air chamber. Provide with factory-mounted electric actuator.

B. Dampers shall be fitted with mohair seals along all sealing edges. Dampers shall use turned-metal principle on long closing ends with no metal-to-metal contact. No plastic or rubber gaskets shall be acceptable. Damper bearings shall be made of nylon or other material which does not require lubrication.

C. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon bearings; with factory-mounted electric actuator.

D. Comply with ASHRAE/IES 90.1.

2.9 ACCESSORIES

A. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.

B. Insulated false back with gasket seals on wall and outdoor-air plenum.
   1. Insulation: Minimum 1/2-inch-thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
      a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
      b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Duct flanges for supply-, return-, and outdoor-air connections.

2.10 BASIC UNIT CONTROLS

A. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

B. Building Automation System (BAS) Interface Requirements:
   1. Interface relay for scheduled operation.
   2. Interface relay to provide indication of fault at the central workstation.
   3. Provide **BACnet** interface for central BAS workstation for the following functions:
      a. Adjust set points.
      b. Unit ventilator start, stop, and operating status.
      c. Data inquiry to include [**outdoor-air damper position,**]supply- and room-air temperature.
      d. Occupied and unoccupied schedules.

C. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive unit ventilators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.

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

3.2 INSTALLATION

A. Install unit ventilators to comply with NFPA 90A.

B. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum 0.25-inchstatic-deflection, elastomeric vibration isolation hanger. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect condensate drain to indirect waste.

B. Connect supply-air and return-air ducts to unit ventilators with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

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. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:
   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.

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

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

END OF SECTION 238223

SECTION 260000 – GENERAL PROVISIONS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The work included in this Contract is shown on the drawings and described in these specifications. It consists of furnishing all labor, material, services, supervision and connection of all systems shown and/or specified including the requirements of:

DIVISION	0	-	BIDDING AND CONTRACT REQUIREMENTS
DIVISION	1	-	GENERAL REQUIREMENTS
DIVISION	26	-	ELECTRICAL
DIVISION	27	-	COMMUNICATIONS
DIVISION	28	-	ELECTRONIC SAFETY AND SECURITY

B. Contractor is responsible to review and understand all drawings and all work of all trades to ensure a complete and thorough project.

C. Provide all labor, tools, materials, equipment, coordination, and plans necessary for installation and proper operation of the electrical systems.

D. Contract drawings and specifications are complementary and must be so used to ascertain all requirements of the work.

1.2 DEFINITIONS

A. Provide, furnish, install, and furnish and install shall have the same meaning. That is, the Contractor shall purchase, transport to the site and install all required components of the work unless specifically stated otherwise in the contract documents.

B. Wiring pertains to raceway, fittings, conductors, terminations, hangers, supports, etc. as required to form a complete system.

1.3 DRAWINGS AND SPECIFICATIONS

A. The plans are diagrammatic and indicate only the sizes and general arrangement of conduit, devices, and equipment; exact locations of all elements shall be determined as work progresses, in cooperation with the work of other trades. It is not intended to show every item of work or minor piece of equipment, but every item shall be furnished and installed without additional remuneration as necessary to complete the system in accordance with the best practice of the trade.

B. As previously stated, the exact locations of electrical devices and equipment is diagrammatic. The owner may request for any devices or equipment to be installed at different locations than what is indicated on the drawings in a specific area or room. It is the responsibility of the Electrical Contractor to coordinate the locations of devices in all areas prior to installation.

1.4 APPLICABLE STANDARDS

A. All equipment shall bear the UL label.

B. The latest edition of the following minimum standards shall apply wherever applicable:

ASA	American Standards Association
ASTM	American Society for Testing Materials
ETL	Electrical Testing Laboratories, Inc.
IEEE	Institute of Electrical and Electronic Engineers
IPCEA	Insulated Power Cable for Engineers Association
OSHA	Occupational Safety and Health Act
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
UL	Underwriters Laboratories, Inc.

Power company standards and regulations.
Local and state codes.

C. In the event there are conflicts between specifications and standards, standards shall govern unless specifications are in excess of standards.

1.5 PERMITS AND INSPECTIONS

A. Permits: The Contractor shall apply for and pay the cost for any local permits necessary for the work of this contract.

B. Inspections: The Contractor shall be responsible for obtaining inspection of and the certificate by a 3rd party inspection agency for the entire electrical system. Turn over certificate of inspection to the architect.

C. The undertaking of periodic inspections by the Owner or Engineer shall not be construed as supervision of actual construction. The Owner or Engineer is not responsible for providing a safe place of work for the Contractor, Contractor's employees, suppliers or subcontractors for access, visits, use, work, travel or occupancy by any person.

1.6 CODES AND REGULATIONS

A. Comply with all applicable rules and regulations of the municipal laws and ordinances and latest revisions thereof. All work shall be done in full conformity with the requirements of all authorities having jurisdiction. Modifications required by the above authorities will be made without additional charges to the Owner. Where alterations to and/or deviations from the Contract Documents are required by the authorities, report the requirements to the Engineer and secure approval before work is started.

B. Furnish and file with the proper authorities, all drawings required by them in connection with the work. Obtain all permits, licenses, and inspections and pay all legal and proper fees and charges in this connection.

C. Should any work shown or specified be of lighter or smaller material than Code requires, same shall be executed in strict accordance with the regulations.

D. Heavier or larger size material than Code requires shall be furnished and installed, if required by the Plans and Specifications.

E. This Contractor shall have the electrical work inspected from time to time by authorized inspectors and shall pay all expense incurred by same. At the completion of the work, the Contractor shall furnish a Certificate of Approval, in triplicate, indicating full approval of the work furnished and installed in this Contract from the local authority having jurisdiction.

F. Equipment and components parts thereof shall bear manufacturer's name-plate, giving manufacturer's name, size, type and model number or serial number, electrical characteristic to facilitate maintenance and replacements. Name plates of distributors or contractors are not acceptable.

G. Engineer will have privilege of stopping any work or use of any material that in his opinion is not being properly installed and each Contractor shall remove all materials delivered, or work erected, which does not comply with Contract Drawings and Specifications, and replace with proper materials, or correct such work as directed by the Engineer, at no additional cost to Owner.

H. If equipment or materials are installed before proper approvals have been obtained, each Contractor shall be liable for their removal and replacement including work of other trades affected by such work, at no additional cost to Owner, if such items do not meet intent of the Drawings and Specifications.

1.7 RECORD DRAWINGS

A. The Electrical Contractor shall keep an accurate location record of all underground and concealed piping, and of all changes from the original design. He is required to furnish this information to the Engineer prior to his application for final payment.
   1. Submit prior to final acceptance inspection, one complete marked-up set of reproducible engineering design drawings.
      a. Fully illustrate all revisions made by all crafts in course of work.
      b. Include all field changes, adjustments, variances, substitutions and deletions, including all Change Orders.
      c. Exact location of raceways, equipment and devices.
      d. Exact size and location of underground and under floor raceways, grounding conductors and duct banks.
   2. These drawings shall be for record purposes for Owner's use and are not considered shop drawings.

B. At completion of the project, all changes and deviations from the Contract Documents shall be recorded by the Contractor.

C. Four (4) corrected sets of all operating and maintenance instructions and complete parts lists bound in hard covers shall be furnished to the Owner.

1.8 CLEANING CONDUIT AND EQUIPMENT

A. Conduit and electrical equipment shall be thoroughly cleaned of dirt, cuttings, and other foreign substances.

1.9 VIBRATION ISOLATION

A. Vibration isolators shall prevent, as far as practicable, transmission of vibration, noise or hum to any part of building.

B. Wiring and other electrical connections to equipment mounted on vibration isolators; made flexible with minimum 180 degree loop of "greenfield" in order to avoid restraining equipment and short circuiting vibration isolator.

1.10 BALANCED LOAD

A. It is intended that design and features of the work as indicated will provide balanced load on the feeders and main service. Contractor shall provide material and installation to provide this balance load insofar as possible.

B. Contractor shall take current and voltage measurements at all panels of at least 1/2 hour. Reconnections of loads shall be made when deemed necessary by the Engineers.

1.11 JOB CONDITIONS

A. Examine site related work and surfaces before starting work of any Section. Failure to do so shall in no way relieve the Contractor of the responsibility to properly install the new work.
   1. Report to the Engineer, in writing, conditions, which will prevent proper provision of this work ten (10) days prior to bid date, in time for an addendum to be issued.
   2. Beginning work of any Section without reporting unsuitable conditions to the Engineer constitutes acceptance of conditions by the Contractor.
   3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.
   4. The Contractor is responsible for performing routine maintenance and cleaning of any existing equipment where he is making connections to new work and to the building where his work adds debris.

B. Connections to existing work:
   1. Install new work and connect to existing work with minimum interference to existing facilities.
   2. Provide temporary shutdowns of existing services only with written consent of Owner at no additional charges and at time not to interfere with normal operation of existing facilities.
   3. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
   4. Do not interrupt alarm and emergency systems.
   5. Connect new work to existing work in neat and acceptable manner.
   6. Restore existing disturbed work to original condition including maintenance of wiring and continuity as required. Replace damaged or rusted conduit to which new equipment is being installed and connected.

C. Removal and relocation of existing work.
   1. Disconnect, remove or relocate electrical material, equipment and other work noted and required by removal or changes in existing construction.
   2. Provide new material and equipment required for relocated equipment.
   3. Disconnect load and line end of conductors feeding existing equipment.
   4. Remove conductors from existing raceways to be rewired.
   5. Remove conductors and cap outlets on raceways to be abandoned.
   6. Dispose of removed raceways and wire.
   7. Dispose of removed electrical equipment as directed by Owner. The Owner shall provide a list of equipment of the Contractor of equipment to be delivered to the Owner.

1.12 SPECIAL TOOLS AND LOOSE ITEMS

A. Furnish to Owner at completion of work:
   1. One set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of this Division.

2. "Special Tools": Those not normally found in possession of maintenance personnel.
3. Keys
4. Redundant components and spare parts.

B. Deliver items to Owner and obtain receipt prior to approval of final payment.

1.13 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by representative of the Engineer.

B. Advise Architect and Engineer that work is ready for review at following times:
1. Prior to backfilling buried work.
2. Prior to concealment of work in walls and above ceilings.
3. When all requirements of contract have been completed.

C. Neither backfill nor conceal work without Engineer's consent.

1.14 SHOP DRAWING SUBMITTALS

A. Submit required shop drawings, samples and product information in accordance with Division 1, requirements and as required in the various sections of these specifications.

B. Submittals shall show evidence of checking by the Contractor for accuracy. Product information (catalog sheets) shall indicate complete catalog number, color, accessories, etc., as well as, name of manufacturer and local distributor or manufacturer’s representative.

C. Submit for review detailed coordination drawings 3/8" or larger scale plans for all major electrical equipment and any areas of conflicts by drafting location of equipment, lighting fixtures, cable trays and conduits larger than 1-1/2" trade size. Contractor shall refer to Division 1 for preparing coordination drawings.

D. Incomplete submittals will be rejected.

E. Additionally, the Contractor will submit data on the following:
1. All electrical equipment including all panelboards and switching devices (disconnects, switches, occupancy sensors, etc.).
2. Fire stop seals used for wall penetrations.
3. Any proposed variation in specified wiring plans and circuitry.
4. All special items and panels, made or constructed specifically for this project, including wiring diagrams, component layout and component data or materials list.
5. All settings of installed equipment, such as overcurrent protection, overload settings, temperature settings, time settings, etc. This includes equipment provided by other contractors or subcontractors and connected and tested by this Contractor.

F. All submittals of NON SPECIFIED equipment and components will be reviewed. It is the submitting Contractor's responsibility to prove compliance and not the Architect/Engineer to prove non-compliance. The submitting Contractor will be charged the prevailing wage of the reviewing Engineer for all submittals requiring over one (1) hour to review that were not originally specified.

1.15 OPERATING INSTRUCTIONS

A. It shall be the Contractor’s responsibility to ensure that the Owner’s representative is given adequate instruction on the operation of all equipment prior to final payment.

1.16 TEMPORARY POWER

A. The Contractor shall provide all temporary power to all trades for all construction locations of this contract. This will include but not be limited to temporary lighting and power outlets.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials and equipment shall be new and as specified or of equal or better quality.

B. Basic hardware and miscellaneous items shall meet existing trade standards of quality and shall carry UL or FM listings where applicable.

C. All equipment supplied shall be the standard equipment of the manufacturer.

D. Multiple items such as panelboards, wiring devices, switches, breakers, raceways, etc., shall be from the same manufacturer.

E. Drawings and specifications are based on specific manufacturer's equipment. Therefore, the Contractor shall assume all responsibility, cost and coordination involved in making any necessary revisions to apply another manufacturer's equipment, even though it may be approved as an "equal" item by the Engineer.

PART 3 - EXECUTION

3.1 COORDINATION OF WORK

A. All work shall be executed in accordance with recognized standards of workmanship. All work shall be installed in a neat and orderly manner.

B. The Contractor shall exchange information with other Contractors and the Owner in order to insure orderly progress of the work.

C. The Contractor must contact the Owner's representative and schedule all work ten (10) days prior to start.

D. The Contractor shall check for possible interference before installing any items. If any work is installed, and later develops interference with other features of the design, the Contractor will be responsible to make such changes to eliminate the interference.

3.2 CEILING REMOVAL

A. Existing ceilings which must be removed for the installation of new work or demolition of existing conditions shall be done by the Contractor. No ceiling shall be removed without prior approval of the Owner. Ceilings which must be removed shall be restored to their original condition as soon as practical and prior to final payment.

B. The removed tile of lay-in type ceilings shall be stored either in the ceiling space or at a designated space in the building. No tiles shall be stored in the occupied space.

C. The Contractor shall take all necessary precautions to prevent damage to the existing ceilings. All damaged ceilings shall be replaced with new ceiling construction to match the existing and to the Owner's satisfaction.

3.3 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Through-Penetration Firestop Systems."

END OF SECTION 260000

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SECTION 260519 – LOW VOLTAGE 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 SUBMITTALS

A. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: In addition to requirements specified in Division 1, an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907; or shall be a full-member company of the InterNational Electrical Testing Association.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

B. Listing and Labeling: Provide wires and cables specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver wires and cables according to NEMA WC 26.

1.6 COORDINATION

A. Coordinate layout and installation of cables with other installations.

B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

a. Okonite
b. American Insulated Wire Corp.; Leviton Manufacturing Co.
c. BICC Brand-Rex Company.
d. Southwire Company.

2. Connectors for Wires and Cables:
a. General Signal; O-Z/Gedney Unit.
b. Square D Co.; Anderson.
c. 3M Company; Electrical Products Division.

2.2 BUILDING WIRES AND CABLES

A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Wire and Insulation Applications" Article.

B. Rubber Insulation Material: Comply with NEMA WC 3.

C. Thermoplastic Insulation Material: Comply with NEMA WC 5.

D. Cross-Linked Polyethylene Insulation Material: Comply with NEMA WC 7.

E. Ethylene Propylene Rubber Insulation Material: Comply with NEMA WC 8.

F. Conductor Material: Copper.

G. Stranded conductors.

2.3 CONNECTORS AND SPLICES

A. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 "Wire and Insulation Applications" Article.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRE AND INSULATION APPLICATIONS

A. Feeders: Type THHN/THWN, in raceway.

B. Branch Circuits: Type THHN/THWN, in raceway.

C. Fire Alarm Circuits: Power-limited, fire-protective, signaling circuit cable.

D. Class 1 Control Circuits: Type THHN/THWN, in raceway.

E. Class 2 Control Circuits: Type THHN/THWN, in raceway.

3.3 INSTALLATION

A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's "Standard of Installation."

B. Remove existing wires from raceway before pulling in new wires and cables.

C. Pull Conductors: 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.

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 Division 26 Section "Basic Electrical Materials and Methods."

G. Seal around cables penetrating fire-rated elements according to Division 7 Section "Firestopping."

H. Identify wires and cables according to Division 16 Section "Electrical Identification."

3.4 CONNECTIONS

A. Conductor Splices: Keep to minimum.

B. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

C. Use splice and tap connectors compatible with conductor material.

D. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

E. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Testing: On installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

B. Correct malfunctioning conductors and cables at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION 260519

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SECTION 260526 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Grounding systems and equipment.

B. Section includes grounding systems and equipment, plus the following special applications:
   1. Overhead-line grounding.
   2. Underground distribution grounding.
   3. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding for sensitive electronic equipment.

B. Qualification Data: For qualified testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch 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 wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet in diameter.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

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 OVERHEAD LINES

A. Comply with IEEE C2 grounding requirements.

B. Install two parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.

C. Drive ground rods until tops are 12 inches below finished grade in undisturbed earth.

D. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.

E. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.

F. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.

G. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.3 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 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 above to 6 inches 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 from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   4. Single-phase motor and appliance branch circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. Armored and metal-clad cable runs.
   8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
   9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
   10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
   1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
   3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

H. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground 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 below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
   1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. 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.

F. 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.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
   1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 24 inches from building's foundation.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.6 LABELING

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
   1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
   3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

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SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.2 DEFINITIONSs

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.3 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

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

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.4 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations

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 products by one of the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.
      c. ERICO International Corporation.
      d. Thomas & Betts Corporation.

e. Unistrut; Tyco International, Ltd.
f. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Hilti Inc.
      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Hilti Inc.
      3) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      4) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted 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.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
   6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
   7. To Light Steel: Sheet metal screws.
   8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

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

B. 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 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, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 9 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES

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 raceways, fittings, connectors and couplings, boxes, enclosures, and cabinets for electrical wiring.
   1. Raceways include the following:
      a. RMC.
      b. IMC.
      c. PVC externally coated, rigid steel conduits.
      d. PVC externally coated, IMC.
      e. EMT.
      f. FMC.
      g. LFMC.
      h. LFNC.
      i. RNC.
      j. ENT.
      k. Wireways.
      l. Surface raceways.
      m. Type MC cable
   2. Boxes, enclosures, and cabinets include the following:
      a. Device boxes.
      b. Floor boxes.
      c. Outlet boxes.
      d. Pull and junction boxes.
      e. Cabinets and hinged-cover enclosures.
      f. Handholes and boxes for underground electrical wiring

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. RMC: Rigid metal conduit.

H. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, hinged-cover enclosures, and cabinets.

B. Shop Drawings: Include layout drawings showing components and wiring for nonstandard boxes, enclosures, and cabinets.

1.5 QUALITY ASSURANCE

A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

B. Comply with NECA's "Standard of Installation."

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Metal Conduit and Tubing:
      a. Alflex Corp.
      b. Anamet, Inc.; Anaconda Metal Hose.
      c. Carol Cable Co., Inc.
      d. Cole-Flex Corp.
      e. Electri-Flex Co.
      f. Flexcon, Inc.; Coleman Cable Systems, Inc.
      g. Grinnell Co.; Allied Tube and Conduit Div.
   2. Nonmetallic Conduit and Tubing:
      a. Anamet, Inc.; Anaconda Metal Hose.
      b. Arnco Corp.
      c. Cantex Industries; Harsco Corp.
      d. Certainteed Corp.; Pipe & Plastics Group.
      e. Cole-Flex Corp.
      f. Condux International; Electrical Products.
      g. Electri-Flex Co.
      h. Hubbell, Inc.; Raco, Inc.
      i. Lamson & Sessions; Carlon Electrical Products.
      j. R&G Sloan Manufacturing Co., Inc.
      k. Thomas & Betts Corp.
   3. Conduit Bodies and Fittings:
      a. American Electric; Construction Materials Group.
      b. Crouse-Hinds; Div. of Cooper Industries.

c. Emerson Electric Co.; Appleton Electric Co.
d. Hubbell, Inc.; Killark Electric Manufacturing Co.
e. Lamson & Sessions; Carlon Electrical Products.
f. O-Z/Gedney; Unit of General Signal.

4. Metal Wireways:
   a. Hoffman Engineering Co.
   b. Keystone/Rees, Inc.
   c. Square D Co.
5. Nonmetallic Wireways:
   a. Hoffman Engineering Co.
   b. Lamson & Sessions; Carlon Electrical Products.
6. Boxes, Enclosures, and Cabinets:
   a. American Electric; FL Industries.
   b. Butler Manufacturing Co.; Walker Division.
   c. Crouse-Hinds; Div. of Cooper Industries.
   d. Electric Panelboard Co., Inc.
   e. Hoffman Engineering Co.; Federal-Hoffman, Inc.
   f. Hubbell Inc.; Killark Electric Manufacturing Co.
   g. Hubbell Inc.; Raco, Inc.
   h. Lamson & Sessions; Carlon Electrical Products.
   i. O-Z/Gedney; Unit of General Signal.
   j. Parker Electrical Manufacturing Co.
   k. Robroy Industries, Inc.; Electrical Division.
   l. Thomas & Betts Corp.

2.2 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. Rigid Aluminum Conduit: ANSI C80.5.

C. IMC: ANSI C80.6.

D. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.

E. Plastic-Coated IMC and Fittings: NEMA RN 1.

F. EMT and Fittings: ANSI C80.3.
   1. Fittings: Set-screw or compression type.

G. FMC: Aluminum.

H. FMC: Zinc-coated steel.

I. LFMC: Flexible steel conduit with PVC jacket.

J. Fittings: NEMA FB 1; compatible with conduit/tubing materials.

2.3 NONMETALLIC CONDUIT AND TUBING

A. ENT: NEMA TC 13.

B. RNC: NEMA TC 2, Schedule 40 or 80 PVC.

C. ENT and RNC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

D. LFNC: UL 1660.

2.4 METAL WIREWAYS

A. Material: Sheet metal sized and shaped as indicated.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

D. Wireway Covers: As indicated

E. Wireway Covers: Hinged type.

F. Wireway Covers: Screw-cover type.

G. Wireway Covers: Flanged-and-gasketed type.

H. Finish: Manufacturer's standard enamel finish.

2.5 CONNECTORS AND COUPLINGS

A. Locknuts: Appleton Electric Co. BL-50 Series, Gould Inc. Efcor 151 Series, Midwest Electric Mfg. Corp. 10 Series, OZ/Gedney Co. 1-50S Series, Raco Inc. 1002 Series, or Thomas & Betts Corp. 141 Series.

B. Grounding Wedge: Thomas & Betts Corp. 3650 Series

C. Couplings (For Rigid and IMC Conduit): Standard threaded couplings as furnished by conduit manufacturer.

D. Three Piece Conduit Coupling (For Rigid and IMC Conduit): Gould Inc. Efcor 165 Series, Midwest Electric Mfg. Corp. 190 Series, OZ/Gedney Co. 4-50 Series, Raco Inc. 1502 Series, or Thomas & Betts Corp. 675 Series

E. Set Screw Type: Appleton Electric Co., Gould Inc. Efcor, Midwest Electric Mfg. Corp., Raco Inc., Tomic Electric, or Thomas & Betts Corp.

F. Flexible Steel Conduit Connectors: Midwest Electric Mfg. Corp. 1708, 1736 Series, OZ/Gedney Co. C-8T, 24-34T, ACV-50T Series, or Thomas & Betts Corp. Nylon insulated Tite-Bite Series.

G. Sealtite Connectors (For Liquidtight Metal Conduit): Appleton Electric Co. STB Series, Crouse-Hinds Co. LTB Series, Gould Inc Efcor 11-50B Series, Ideal Industries Inc. 75-521 Series, Midwest Electric Mfg. Corp. LTB Series, OZ/Gedney Co. 4Q-50T Series, Raco Inc. 3512 Series, or Thomas & Betts Corp. 5332 Series.

2.6 FLOOR BOXES

A. Floor Boxes: metallic or nonmetallic.

B. Provide with leveling plate and mud cap for protection during concrete pour of floor slab.

C. Provide with (2) internal duplex receptacle brackets.

D. Provide with brushed metal cover - finish to be determined by architect at submittal time. Cover to be gasketed for general floor mopping and include (2) flip lid doors, opening 180 degrees.

E. Box: Leviton FBBOX-GY

F. Leveling Ring: Leviton FBLEV-GY

G. Cover: Leviton FBC2F

2.7 OUTLET AND DEVICE BOXES

A. Sheet Metal Boxes: NEMA OS 1.

B. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.

2.8 PULL AND JUNCTION BOXES

A. Small Sheet Metal Boxes: NEMA OS 1.

B. Cast-Metal Boxes: NEMA FB 1, cast aluminum with gasketed cover.

2.9 ENCLOSURES AND CABINETS

A. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

B. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment.

2.10 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Polymer concrete with galvanized-steel frame and cover, prototype tested for compliance with SCTE 77.
   1. Configuration: Open bottom.
   2. Weatherproof cover.
   3. Cover Legend: "ELECTRIC." and “COMMUNICATIONS”

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRING METHODS

A. Outdoors: Use the following wiring methods:
   1. Exposed: Rigid steel.
   2. Concealed: Rigid steel.
   3. Underground, Single Run: RNC.
   4. Underground, Grouped: RNC.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   6. Boxes and Enclosures: NEMA 250, Type 3R or Type 4.

B. Indoors: Use the following wiring methods:
   1. Exposed: EMT. Non-metallic and metallic surface raceways as shown on associated electrical drawings.

2. Concealed: EMT
3. Concealed in slab on grade: RNC (transition to 90 degree rigid steel elbow prior to exiting floor slab on grade)
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except in wet or damp locations, use LFMC.
5. Damp or Wet Locations: Rigid steel conduit.
6. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
   a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.

3.3 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Minimum Raceway Size: 3/4-inch trade size. Unless otherwise noted

C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

D. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom.

F. Complete raceway installation before starting conductor installation.

G. Support raceways as specified in Division 26 Sections "Hangers and Supports for Electrical Systems" and "General Provisions for Electrical Work."

H. Use temporary closures to prevent foreign matter from entering raceways.

I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

J. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

K. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.

L. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.

M. Raceways Embedded in Slabs: Install in middle third of slab thickness where practical, and leave at least 1-inch concrete cover.
   1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
   2. Space raceways laterally to prevent voids in concrete.
   3. Run conduit larger than 1-inch trade size parallel to or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   4. Transition from nonmetallic tubing to Schedule rigid steel conduit before rising above floor.

N. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
   1. Run parallel or banked raceways together, on common supports where practical.

2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

O. Join raceways with fittings designed and approved for the purpose and make joints tight.
1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings to protect conductors.

P. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.

Q. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

R. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of the pull wire.

S. Telephone and Signal System Raceways, 2-Inch Trade Size and Smaller: In addition to the above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

T. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as the boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

U. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.

V. Flexible Connections: Use maximum of 6 feet of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid tight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.

W. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in a nonmetallic sleeve.

X. Do not install aluminum conduits embedded in or in contact with concrete.

Y. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.

Z. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying the raceways to receptacle or fixture ground terminals.

1. Select each surface raceway outlet box, to which a lighting fixture is attached, of sufficient diameter to provide a seat for the fixture canopy.
2. Where a surface raceway is used to supply a fluorescent lighting fixture having central-stem suspension with a backplate and a canopy (with or without extension ring), no separate outlet box is required.
3. Provide surface metal raceway outlet box, and the backplate and canopy, at the feed-in location of each fluorescent lighting fixture having end-stem suspension.
4. Where a surface metal raceway extension is made from an existing outlet box on which a lighting fixture is installed, no additional surface-mounted outlet box is required. Provide a backplate slightly smaller than the fixture canopy.

AA. Set floor boxes level and adjust to finished floor surface.

BB. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.4 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.5 CLEANING

A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 260533

SECTION 260544 - SLEEVES & SLEEVE SEALS FOR ELECTRICAL RACEWAYS & CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:
1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:
1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. 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. Advance Products & Systems, Inc.
      b. CALPICO, Inc.
      c. Metraflex Company (The).
      d. Pipeline Seal and Insulator, Inc.
      e. Proco Products, 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 or stainless steel.
   4. Connecting Bolts and Nuts: carbon steel, with corrosion-resistant coating or stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

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

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

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

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

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
   2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
      b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
   2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
   4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
   5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

END OF SECTION 260544

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SECTION 260553 - ELECTRICAL IDENTIFICATION

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 electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
   1. Color: Black letters on orange field.
   2. Legend: Indicates voltage and service.

B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend over laminated with a clear, weather- and chemical-resistant coating.

C. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

D. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

E. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.
   1. Not less than 6 inches wide by 4 mils thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip or core.
   4. Printed legend indicating type of underground line.

F. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

G. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch- thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

H. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

I. Aluminum-Faced, Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and preprinted with legends to suit each application.

J. Brass or Aluminum Tags: 2 by 2 by 0.05-inch metal tags with stamped legend, punched for fastener.

2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength: 50 lb minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: According to color-coding.

B. Paint: Formulated for the type of surface and intended use.
   1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
   2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
   3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
   4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.

C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before applying.

E. Install painted identification according to manufacturer's written instructions and as follows:
   1. Clean surfaces of dust, loose material, and oily films before painting.
   2. Prime surfaces using type of primer specified for surface.
   3. Apply one intermediate and one finish coat of enamel.

F. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:
   1. Bands: Pretensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
   2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
   3. Apply the following colors to the systems listed below:
      a. Fire Alarm System: Red.
      b. Fire-Suppression Supervisory and Control System: Red and yellow.
      c. Combined Fire Alarm and Security System: Red and blue.
      d. Security System: Blue and yellow.
      e. Mechanical and Electrical Supervisory System: Green and blue.
      f. Telecommunication System: Green and yellow.

G. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

H. Circuit Identification Labels on Boxes: Install labels externally.
   1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
   2. Concealed Boxes: Plasticized card-stock tags.
   3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

I. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

J. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.
   1. Color-code 208/120-V system as follows:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
d. Neutral: White.
e. Ground: Green.

2. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:
   a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.

K. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.
1. Legend: 1/4-inch- steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
2. Tag Fasteners: Nylon cable ties.
3. Band Fasteners: Integral ears.

L. Apply identification to conductors as follows:
1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

M. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

N. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch- high lettering on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
1. Panelboards, electrical cabinets, and enclosures.
2. Individual breakers on main switchboard.
3. Access doors and panels for concealed electrical items.
4. Electrical switchgear and switchboards.
5. Electrical substations.
6. Emergency system boxes and enclosures.
7. Motor-control centers.

8. Disconnect switches.
9. Enclosed circuit breakers.
10. Motor starters.
11. Push-button stations.
12. Power transfer equipment.
13. Contactors.
14. Remote-controlled switches.
15. Dimmers.
16. Control devices.
17. Transformers.
18. Inverters.
19. Rectifiers.
20. Frequency converters.
21. Battery racks.
22. Power-generating units.
23. Telephone switching equipment.
24. Clock/program master equipment.
25. Call system master station.
26. TV/audio-monitoring master station.
27. Fire alarm master station or control panel.
28. Security-monitoring master station or control panel.

END OF SECTION 260553

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SECTION 260923 – LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Photoelectric switches.
2. Indoor occupancy sensors.
3. Indoor vacancy sensors.
4. Dimming switches.
5. Lighting contactors.

B. Related Requirements:
1. Section 262726 "Wiring Devices" for wall-box dimmers, manual light switches, and color/finish of devices and faceplates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show installation details for occupancy sensors.
1. Interconnection diagrams showing field-installed wiring.
2. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. NSi Industries LLC; TORK Products.
4. Tyco Electronics; ALR Brand.
5. Paragon.

B. Description: Solid state, with SPST or DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.

3. Time Delay: Fifteen second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.2 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
   1. Lighting control set point is based on two lighting conditions:
      a. When no daylight is present (target level).
      b. When significant daylight is present.
   2. System programming is done with two hand-held, remote-control tools.
      a. Initial setup tool.
      b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

B. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated or separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.

C. Electrical Components, Devices, and Accessories:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
   3. Light-Level Sensor Set-Point Adjustment Range: 20 to 100 fc (120 to 1080 lux).

D. Power Pack: Dry contacts rated for 20-A load at 120- and 277-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
   1. LED status lights to indicate load status.
   2. Plenum rated.

E. Power Pack: Digital controller capable of accepting RJ45 inputs with two outputs rated for 20-A load at 120- and 277-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
   1. With integral current monitoring
   2. Compatible with digital addressable lighting interface.
   3. Plenum rated.

2.3 INDOOR OCCUPANCY SENSORS

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. Hubbell Lighting Controls.
   2. Greengate Lighting Controls.
   3. Cooper Industries.
   4. Lithonia Lighting; Acuity Lighting Group, Inc.
   5. Lutron Electronics Co., Inc.
   6. Sensor Switch, Inc.
   7. Watt Stopper.

B. General
   1. Occupancy sensors shall control lighting in the controlled area only.
   2. The contractor shall be responsible for a complete, operable system, providing the control as indicated on the drawings, and installation should be warranted for a period of one (1) year after owner’s acceptance.

3. Drawings show devices required for operational intent. It will be the responsibility of the contractor to provide the correct digital solution where required. For clarity, all components are not shown on plan.
4. The product shall be warranted for a period of five (5) years for wall switch sensors, ceiling sensors and power packs.
5. Occupancy sensors shall be installed as per manufacturer's recommendations.
6. The specified manufacturers have different types of sensors with different areas of coverage. The contractor shall be responsible for contacting the manufacturer for proper placement and adjustment of sensor. Drawings indicate general locations of sensors to indicate area of control only.
7. The contractor shall provide additional sensors and control units as necessary to provide control of the indicated area.
8. Individual room sensors shall not be activated by motion outside of the room when the room door is open.
9. Sensors shall be provided with auxiliary contacts for HVAC fan occupancy control.

C. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operation: 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.
3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
5. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
7. Bypass Switch: Override the "on" function in case of sensor failure.
8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
9. Dual Relay Units: Shall have provisions for setting both relays to turn on when occupancy is detected. Units that allow only one relay to default to "on" are not acceptable.
10. Occupancy sensor to be compatible with all other lighting controls and light fixtures in room. Contractor and lighting supplier to verify coordination prior to submittal and shall be responsible to replace any devices that do not operate as intended.

D. Ceiling Mounted Occupancy Sensor for Low Voltage Dimming:
1. Dual-Technology Type. Uses a combination of passive-infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered.
2. Provides dimming outputs to control 0-10Vdc dimmable drivers.
3. Follows dimming commands from nLight Wallpod dimmer or SensorView software.
4. Capable to communicate with other nLight devices over Cat5e cable.
5. Adds 20 AWG violet & gray wires.

6. Extended range (28’ radius, 360 degrees) coverage pattern
7. Compatible with LED dimming drivers
8. Auto dimming control photocell.

E. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
4. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
5. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
6. Ceiling sensor to be provided with isolated relay for integration with Building HVAC management system.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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. Hubbell Lighting Controls.
2. Greengate Lighting Controls.
3. Cooper Industries, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Lutron Electronics Co., Inc.
6. Sensor Switch, Inc.
7. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

C. Vacancy Sensor with integral 0-10v manual dimming control.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Switch Rating: Not less than 800-VA fluorescent/LED at 120 V and 1200-VA fluorescent/LED at 277 V.
4. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
5. Sensing Technology: Dual technology (PIR and ultrasonic).
6. Switch Type: Single-relay or dual-relay, as indicated on drawing.
   a. Dual-Relay Units: Shall have provisions for setting both relays to turn on when occupancy is detected. Units that allow only one relay to default to “on” are not acceptable.
7. Voltage: Match the circuit voltage.
8. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
9. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.

10. Concealed "off" time-delay selector at 30 seconds, and 5, 10, and 20 minutes.
11. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
12. Color/finish shall match that of other wiring devices in the project.
13. Sensor to be compatible with all other lighting controls and light fixtures in room. Contractor and lighting supplier to verify coordination prior to submittal and shall be responsible to replace any devices that do not operate as intended.

2.5 DIMMER SWITCH

A. Description: Wall box dimmer switch.
1. On/Off switch with buttons or slider to raise/lower light level.
2. 0-10v dimming control.
3. Compatible with associated dimming driver in luminaire.
4. Finish of decorator switch to be ivory.
5. Wall plate to be satin-finished stainless steel.
6. Multiple gang face plates to accommodate quantity of switches required.
7. Provide additional components (digital room system, power supplies, etc.) if required to wire system.
8. Manufacturers:
    a. Wattstopper, Inc.
    b. Lutron
    c. Hunt Dimming

2.6 LOW VOLTAGE WALL MOUNTED OCCUPANCY SENSOR WITH DIMMING CONTROL

A. Description: Low voltage occupancy sensor wall switch with buttons for on/off, raise light level, and lower light level.
1. Dual-Technology Type. Uses a combination of passive-infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered. Particular technology or combination of technologies that controls each function (on or off) is selectable in the field by operating controls on unit.
2. 0-10v dimming control.
3. Capable to communicate with other nLight devices over Cat5e cable.
4. Capable to control other 0-10v drivers.
5. Adds 20 AWG violet & gray wires.
6. Finish of decorator switch to be ivory. Finish of faceplate to be satin-finished stainless steel. Size of plate to be dependent upon existing/new box size.
7. Sensorswitch, Model #nWSX LV DX IV

2.7 LOW VOLTAGE DIMMING SWITCH

A. Description: Low voltage wall switch with buttons for on/off, raise light level, and lower light level.
1. 0-10v dimming control.
2. Capable to communicate with other nLight devices over Cat5e cable.
3. Capable to control other 0-10v drivers.
4. Adds 20 AWG violet & gray wires.
5. Finish of decorator switch to be ivory. Finish of faceplate to be satin-finished stainless steel. Size of plate to be dependent upon existing/new box size.
6. Sensorswitch, Model #nPODM DX IV

2.8 AUXILIARY RELAY

A. Description: Auxiliary relay pack that enables switching of low voltage interface with non-nLight devices or control systems.
   1. Capable to communicate with nLight Network over Cat 5e cable
   2. Remotely Configurable/Upgradeable
   3. Push-Button Programmable
   4. Reversible Relay Logic
   5. Green LED Indicator
   6. Two RJ-45 connectors for Cat 5e cabling
   7. Can be daisy chained with nLight-enabled power packs, sensor and/or WallPods in an nLight control zone.
   8. Operational Settings.
      a. Overide (On/Off/Normal)
      b. Occupancy Tracking (Enable/Disable)
      c. Photocell Tracking (Enable/Disable)
      d. Switch Tracking (Enable/Disable)
      e. Occupancy Tracking Channel (1-16)
      f. Photocell Tracking Channel (1-16)
      g. Switch Tracking Channel (1-16)
      h. Button Mode (Enable/Disable)
      i. Start to High (Enable/Disable)
      j. Invert Relay Logic (Enable/Disable)
      k. LED (Override On/Override Off/Normal)
   9. Special Modes: Manual On to Auto off (Semi-Auto), Auto to (Timed) Override On, Manual to (Timed) Override On, Manual On to Full Auto, Predictive off.
   10. Sensorswitch, Model #nAR40

2.9 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 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "Low Voltage Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After installing 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.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two 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.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

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SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

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. Accessory components and features.
5. Identification.
6. Mimic bus.

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. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. 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.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. 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 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 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.

B. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 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.

C. Handle and prepare switchboards for installation according to NECA 400.

1.9 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 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).

C. Unusual Service Conditions: NEMA PB 2, as follows:
1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Construction Manager and Owner no fewer than ten (10) days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's and Owner's written permission.
4. Comply with NFPA 70E.

1.10 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.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Three (3) years from date of Substantial Completion.

B. 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 (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Square D; by Schneider Electric
2. Eaton.

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. Front- and Side-Accessible Switchboards:
1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Section Alignment: Front and Rear aligned.

J. Nominal System Voltage: As indicated on associated electrical drawings.

K. Main-Bus Continuous: As indicated on associated electrical drawings.

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. Barriers: Between adjacent switchboard sections.

O. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchboard.

R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

S. Pull Box on Top of Switchboard:
1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

T. 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 mechanical 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 mechanical connectors for feeder and branch-circuit ground conductors.
6. 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.
7. Disconnect Links:
   a. Isolate neutral bus from incoming neutral conductors.
   b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

U. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

V. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

2.2 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Square D; by Schneider Electric
2. Eaton.

B. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

D. Features and Accessories:
1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 250kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V
3. Line to Line: 2000 V for 480Y/277 V.

G. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:
1. Line to Neutral: 700 V.
2. Line to Ground: 1000 V.
3. Line to Line: 1000 V.

H. Nominal Rating: 20 kA.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with [series-connected rating] [interrupting capacity] to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long and short time adjustments.
   d. 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. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Time adjustments for long- and short-time pickup.
   c. Ground-fault pickup level, time delay, and I squared t response.

2.4 INSTRUMENTATION

A. 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.
      j. Contact devices to operate remote impulse-totalizing demand meter.
   2. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.

2.5 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
   1. Nameplate: At least 0.032-inch- (0.813-mm-) thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
   1. Nameplate: At least 0.0625-inch- (1.588 mm-) thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. 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.
   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. Coordinate all phasing of work with project manager. Provide timelines for each step. Include disconnection of existing utility service and distribution feeders, removal of switch and distribution sections, installation of new gear sections, reconnection of feeders, and installation and reconnection of new utility secondary conductors.

B. Install switchboards and accessories according to NECA 400.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. 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.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation.
1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

3.4 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 an engraved plastic laminate nameplate

complying with requirements for identification specified in Section 260553 "Electrical Identification."

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 with the assistance of a factory-authorized service representative.

E. Tests and Inspections:
   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. Perform the following infrared scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Switchboard will be considered defective if it does not pass tests and inspections.

G. 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.

3.6 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 indicated.

3.7 PROTECTION

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

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories and to use and reprogram any microprocessor-based trip, monitoring, and communication units.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:
   1. Lighting and appliance branch-circuit panelboards.
   2. Distribution panelboards.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, TVSS device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Enclosure types and details for types other than NEMA 250, Type 1.
      b. Bus configuration, current, and voltage ratings.
      c. Short-circuit current rating of panelboards and overcurrent protective devices.
      d. UL listing for series rating of installed devices.
      e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

D. Field Test Reports: Submit written test reports and include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

F. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1, 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.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.7 EXTRA MATERIALS

A. Keys: Six spares of each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories (Panelboard dimensions on associated electrical drawings are based on Square D equipment. Electrical contractor is responsible for layout of equipment if equivalent manufacturer is accepted):
      a. Square D Co.
      b. Eaton Corp.; Cutler-Hammer Products.

2.2 FABRICATION AND FEATURES

A. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
   1. Outdoor Locations: NEMA 250, Type 4X
   2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

B. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

C. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

D. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

E. Bus: Hard-drawn copper, 98 percent conductivity.

F. Main and Neutral Lugs: Compression type suitable for use with conductor material.

G. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

H. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

I. Feed-through Lugs: Compression type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

2.3 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rated panelboards will not be accepted.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike; directory frame

C. Fronts: piano hinged cold–rolled sheet steel with gray lacquer finish, furnished with concealed latch for securing hinged front to box. Furnish piano hinged front on all panelboards. All flush finished areas shall be provided with the piano hinge attached to the back box with flush flathead screws. Include door.

2.5 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.

B. Main Overcurrent Protective Devices: Circuit breaker.

C. Branch overcurrent protective devices shall be one of the following:

D. For Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.

E. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.6 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, 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. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.

B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
   1. Lugs: Compression style, suitable for number, size, trip ratings, and material of conductors.
   2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
   3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
   4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: To test functions of solid-state trip devices without removal from panelboard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

C. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

D. Install filler plates in unused spaces.

E. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

F. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case 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. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.5 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262416

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SECTION 262616 - 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 Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
   1. Service disconnecting means.
   2. Feeder and branch-circuit protection.
   3. Motor and equipment disconnecting means.

B. Related Sections include the following:
   1. Division 26 Section "Wiring Devices" for attachment plugs, receptacles, and toggle switches used for disconnecting means.
   2. Division 26 Section "Fuses" for fusible devices.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. RMS: Root mean square.

C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switch and circuit breaker.
   1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Enclosure types and details for types other than NEMA 250, Type 1.
      b. Current and voltage ratings.
      c. Short-circuit current rating.
      d. UL listing for series rating of installed devices.
      e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces. Include the following:
   1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Field Test Reports: Submit written test reports and include the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Manufacturer's field service report.

G. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1, include the following:
1. Routine maintenance requirements for components.
2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA AB 1 and NEMA KS 1.

D. Comply with NFPA 70.

E. 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.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Verify existing panelboard KAIC ratings for installation of new breakers. New breakers to be added to existing panelboards shall be U.L. listed/labeled for use with the existing panelboards. Interrupting rating of new breakers shall match rating of existing associated panelboard.

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. Spares: For the following:
      a. Control-Power Fuses: 2
      b. Fuses for Fused Switches: 2
   2. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Square D Co.
   2. Eaton Corp.; Cutler-Hammer Products.

2.2 ENCLOSED SWITCHES

A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.

2.3 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
   1. Outdoor Locations: NEMA 250, Type 3R.
   2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.4 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard gray paint applied to factory-assembled and -tested enclosures before shipping.

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

3.2 INSTALLATION

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

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section “Electrical Identification”.

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.

B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

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 and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
   2. Test continuity of each line- and load-side circuit.

B. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches. 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. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
   2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switches and circuit breakers checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262616

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SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Receptacles, Snap switches, Faceplates, Cord Reels, Floor box service outlets, Speakers, and Infrared Safety system for overhead powered doors.

1.2 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.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.4 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.

D. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 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 application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
   1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
   2. Devices shall comply with the requirements in this Section.

2.3 RECEPTACLES

A. Straight-Blade Receptacles: 20 amp, 125 volts, 2 pole, 3 wire, U ground slot, Heavy-Duty Specification Grade. Ivory in color.

B. GFCI Receptacles: Feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle, arranged to protect connected downstream receptacles on same circuit. Design units for installation in a 2-3/4-inch- deep outlet box without an adapter. Heavy-Duty Specification Grade. Ivory in color.

C. Straight-Blade Tamper Resistant Receptacles: 20 amp, 125 volts, 2 pole, 3 wire, U ground slot, Heavy-Duty Specification Grade. Dual mechanism shutter system to help prevent insertion of foreign objects. Ivory in color.

D. Weather-Resistant Receptacles: Outdoor grade, UL Listed weather-resistant to comply with Section 406.8 of the 2008 National Electrical Code. Constructed with UV stabilized engineering thermoplastic for high cold impact resistance.

2.4 COMBINATION USB CHARGER & TAMPER RESISTANT RECEPTACLES

A. Two Straight-Blade Tamper Resistant Receptacles: 20 amp, 125 volts, 2 pole, 3 wire, U ground slot, NEMA 5-20R.

B. Two high powered USB ports with 3.6A of charging power, 5VDC.

C. Decora tamper-resistant receptacle/outlet.

D. Ivory in color.

E. Leviton, model #T5832-I.

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper; CWL520R.
      b. Hubbell; HBL2310.
      c. Leviton; 2310.
      d. Pass & Seymour; L520-R.

2.6 SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Snap Switches, 120/277v: Quiet slow make, slow break design, toggle handle with totally enclosed case, rated 20 amp, specification grade. Provide matching two pole, 3 way, and 4 way switches.

C. Grounding Combination Switches: Rated 20 amp, specification grade, two single pole switches. For use where two switches shall be installed in existing single gang device box to accommodate inboard/outboard switching.

D. Pilot Light Switch: 120v, 20a Single pole, with neon-lighted handle, illuminated when switch is "on" – (light on with load on).

E. Single and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.

F. All switches shall be Ivory in color.

2.7 WALL PLATES

A. Single and combination types match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.04-inch- thick, Type 302, satin-finished stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Weatherproof plates: Cast metal, gasketed. For receptacles, provide spring loaded gasket doors.
5. For receptacles with other than 120 volts, inscribe plate with voltage available.

2.8 RETRACTABLE POWER CORD REELS

A. Heavy duty retractable 50 foot cord reel with duplex outlet box with GFCI protection.

B. 20A, 125v rating.

C. Spring retractable with 50 foot, 12/3 SEOOW cord.

D. Heavy-duty reinforced steel construction.

E. Powder coated, corrosion resistant red finish.

F. Heavy duty collector ring.

G. Grounded extension cord with built-in circuit breaker for protection.

H. Overall Weight – 45 lbs.

I. Manufacturer: Reelcraft, Model #L 5550 123 7A.

J. Cord reel to be hardwired to branch circuit wiring.

2.9 RECESSED FLOOR BOX FOR SERVICE OUTLETS

A. Type: Modular, flush-type, service units suitable for wiring method used.

B. 2-gang unit with internal duplex receptacle brackets.

C. Service Plate: Round with satin nickel finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish.

E. Die-cast aluminum cover to have (2) sliding door openings that lock in the open position and auto close around cables when the covers are closed. Cover to have 8-degree beveled edge that meets ADA guidelines.

F. Manufacturer: Wiremold Legrand, Model RFB2E with RFB6DP receptacle brackets and Evolution Series cover #6CTC2SN.

2.10 SPEAKERS AND PUBLIC ADDRESS SYSTEM COMPONENTS

A. Flush recessed ceiling mount speakers: Unit shall consist of an 8" cone type speaker with attached 25V/70V line matching transformer and exhibit the following characteristics:
1. Frequency range: 65Hz to 17KHz or wider.

2. Power rating: 8 watts RMS.
3. Sensitivity: Minimum 93dB at 4 foot with 1 watt input.
4. Magnet weight: Minimum 5 ounces ceramic.
5. Voice coil impedance: 8 ohms.
6. Transformer: 25/70V line matching transformer with taps for 5/16, 5/8, 1-1/4, 2-1/2, and 5 watts minimum.
7. Speaker assembly with speaker, transformer and round baffle.
8. Rauland-Borg model ACC1400, with backbox ACC1101and t-bar support ACC1104.

B. Wall/Surface Mount Speaker Assembly: Unit shall consist of an 8" speaker with attached 25V/70V line matching transformer and exhibit the following characteristics:
1. Frequency range: 65Hz to 17KHz or wider.
2. Power rating: 8 watts RMS.
3. Sensitivity: Minimum 93dB at 4 foot with 1 watt input.
4. Magnet weight: Minimum 5 ounces ceramic.
5. Voice coil impedance: 8 ohms.
6. Transformer: 25/70V line matching transformer with taps for 5/16, 5/8, 1-1/4, 2-1/2, and 5 watts minimum.
7. Baffle 11" square, 5-1/2" deep top, 3 1/8" deep bottom, 22 gauge steel.
8. Rauland-Borg model ACCWB5.

C. Horn Speaker: to consist of a heavy-duty horn type speaker with integral 25V/70V line matching transformer. Characteristics to be as follows:
1. Frequency response: 225Hz to 14KHz or wider.
2. Power handling capacity: 30 watts program material, 60 watts peak.
3. Dispersion: 120 degrees horizontal, 60 degrees vertical.
4. Sensitivity: Minimum 107dB at 1 meter with 1 watt input.
5. Transformer: 25V line matching transformer with taps for 1.8, 3.7, 7.5, and 15 watts minimum.
6. Rauland-Borg 3603 Wide-angle Paging Horn.

D. PA System Circuit Card

E. PA System Terminal Block

2.11 DOOR MOTION SENSORS (INFRARED SAFETY SYSTEM FOR OVERHEAD POWERED DOORS)

A. Summary: The safety detection system shall create an infrared barrier at each side of the entire operation path so that immediate shut down will occur if any personnel obstruction enters into the operating path.

B. The infrared system provided shall be compatible to work as an integral part of the operable partition system. Provide with a remote sensor control panel with a dry contact to door control box if not compatible. Coordinate equipment with General Contractor providing Sky-fold door.

C. While the partition is in operation a minimum of two (2) infrared sensors monitor each side of the partition for movement and immediately sends a signal to the door control box to disengage the motor.

D. Beams must span the entire path of the partition on both sides, a minimum of four (4) sensors being used. These long-range sensors will be mounted on the ceiling and pick up motion no more than seven (7) feet, no less than three (3) feet during opening and closing modes of the powered door.

E. Manufacturer: OPTEX, Model #SP-80 AM High Sensitivity (PIR) Device.

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 meet provisions of 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. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. 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.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. 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.

H. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Specification Section "Electrical Identification."

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.

3.4 FIELD QUALITY CONTROL

A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

3.5 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cartridge fuses, rated 600 V and less, for use in switches.

1.3 SUBMITTALS

A. Product Data: Include the following for each fuse type indicated:
   1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   2. Let-through current curves for fuses with current-limiting characteristics.
   3. Time-current curves, coordination charts and tables, and related data.
   4. Fuse size for elevator feeders and elevator disconnect switches.

B. Ambient Temperature Adjustment Information. If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses adjusted.
   1. For each adjusted fuse, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

C. Maintenance Data: For tripping devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Provide fuses from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.
   1. Fuses: Quantity equal to 10 percent of each fuse type and size, but not fewer than 1 of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Industries, Inc.; Bussmann Div.
   2. General Electric Co.; Wiring Devices Div.
   3. Gould Shawmut.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK1, time delay.

B. Other Branch Circuits: Class RK1, time delay.

C. Plug –in Bus Disconnects: Class J fuses.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 262813

SECTION 264113 - LIGHTNING PROTECTION

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 lightning protection for the cafeteria addition of the Heritage Middle School of the Newburgh ECSD.

B. This Section includes an extension to the existing lightning protection system.

C. Section includes lightning protection system for the following:
   1. Ordinary building structures.
   2. Rooftop mounted HVAC equipment.

1.3 DEFINITIONS

A. LPI: Lightning Protection Institute.

B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

C. Include raceway locations needed for the installation of conductors.

D. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.

E. Include roof attachment details, coordinated with roof installation.

F. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.

G. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

H. Field inspection reports indicating compliance with specified requirements.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Lightning protection cabling attachments to roofing systems and accessories.
   2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.

3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.

B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.7 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

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:

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

1. Baker Lightning Rod Protection or approved equivalent.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96.

B. Roof-Mounting Air Terminals: NFPA Class I, aluminum, unless otherwise indicated.

1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.

C. Stack-Mounting Air Terminals: Stainless steel.

D. Air Terminal Bracing: Aluminum

E. Main Conductors and Downcomer: 57 kcmil (#2 AWG)

F. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding" and with standards referenced in this Section.

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 sharp bends and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 100 feet of building. Comply with requirements for concealed installations in NFPA 780.
   1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
   2. Install conduit where necessary to comply with conductor concealment requirements.

D. A ground ring installation based on requirements in Section 260526 "Grounding and Bonding for Electrical Systems" may be used as a ground loop for the lightning protection system, provided the counterpoise conductor complies with or exceeds minimum NFPA 780 requirements.

E. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

F. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

G. The counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding" may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.

   1. Bond ground terminals to counterpoise conductor.
   2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.
   3. Bond grounded metal bodies on building within 12 feet of roof to interconnecting loop at eave level or above.

H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 CABLE 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. Above ground exposed connections shall be done using the following types of connectors, listed, and labeled for the purpose: bolted connectors or high compression crimp.

C. Bonded 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 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.

B. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION 26411

SECTION 265100 - INTERIOR LIGHTING

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. Interior lighting fixtures with LED lamps.
2. Lighting fixtures mounted on exterior building surfaces.
3. Exit signs.
4. Emergency Lighting Units
5. Accessories.

B. Related Sections include the following:
1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors and manual wall-box dimmers for LED fixtures.

1.3 DEFINITIONS

A. CRI: Color rendering index.

B. CU: Coefficient of utilization.

C. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. LER: Luminaire efficiency rating, which is calculated according to NEMA LE 5. This value can be estimated from photometric data using the following formula:
1. LER is equal to the product of total rated lamp lumens times BF times luminaire efficiency, divided by input watts.

E. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. All lighting fixture types shall be submitted at the same time. Information on each fixture shall include data on features, accessories, and the following:
1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Photometric ies files will be submitted for all fixture substitutions.

B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

C. Coordination Drawings: Reflected ceiling plan(s) 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. Lighting fixtures.
2. Suspended ceiling components.
3. Structural members to which suspension systems for lighting fixtures will be attached.

4. Other items in finished ceiling including the following:
   a. Air outlets and inlets.
   b. Speakers.
   c. Sprinklers.
   d. Smoke and fire detectors.
   e. Occupancy sensors.
   f. Access panels.
5. Perimeter moldings.

D. All submittals of NON-SPECIFIED fixtures must include documentation, or they will be automatically rejected.

E. Wiring Diagrams: Power, signal, and control wiring.

F. Samples for Verification:
1. For interior lighting fixtures designated for sample submission in the Interior Lighting Fixture Schedule.
   a. Lamps: Specified units installed.
   b. Ballast: 120-V models of specified ballast types.
   c. Accessories: Cords and plugs.
2. Substitution fixtures as requested by the engineer at time of submittal.
   a. Lamps: Specified units installed.
   b. Ballast: 120-V models of specified ballast types.
   c. Accessories: Cords and plugs.
3. Paint sample for light poles and associated luminaires.
4. Paint sample for decorative interior fixtures.

G. Footcandle Point x Point layouts for areas where substitutions have been offered.

H. Product Certificates: For each type of driver for dimmer-controlled fixtures, signed by product manufacturer.

I. Source quality-control test reports.

J. Field quality-control test reports.

K. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section Closeout Procedures include the following:
1. Catalog data for each fixture. Include the diffuser, driver, and LED data.

L. Warranties: Special warranties specified in this Section.

M. Submittals that fail to comply with the above requirements will automatically be rejected.

N. It is the Contractor’s responsibility to provide submittals in an organized and timely manner in order so as not to delay the project schedule and hamper the work of other trades.

O. All submittals of NON-SPECIFIED equipment and components will be reviewed. It is the submitting Contractor's responsibility to prove compliance and not the Architect/Engineer to prove non-compliance. The submitting Contractor will be charged the prevailing wage of the reviewing Engineer for all submittals requiring over one (1) hour to review that were not originally specified.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

D. Comply with NFPA 70.

E. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Refer to Luminaire Schedule for specified products and manufacturers.
   1. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a product of equal performance, aesthetics, and construction.
   2. Non-specified products will be subject to possible request of point-by-point calculations and samples for comparison.

2.2 FIXTURES AND COMPONENTS, GENERAL

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Metal Parts: Free of burrs and sharp corners and edges.

C. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

D. Doors, Frames, and Other Internal Access: 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.

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.
4. Laminated Silver Metallized Film: 90 percent.

F. Plastic Diffusers, Covers, and Globes:
1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   a. Lens Thickness: At least 0.125 inch minimum unless different thickness is scheduled.
   b. UV stabilized.
2. Glass: Annealed crystal glass, unless otherwise indicated.
3. All fixture lenses shall meet ASTM E-84, maximum smoke developed of 450 and ASTM E-635, maximum burn rate of 2.5 inches per minute.

G. Electromagnetic-Interference Filters: A component of fixture assembly. Suppress conducted electromagnetic-interference as required by MIL-STD-461D. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

H. Finishes: Manufacturer's standard unless otherwise indicated.
1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
2. Metallic Finish: Corrosion resistant.

2.3 EXIT SIGNS

A. General: Comply with UL 924; for sign colors and lettering size, comply with authorities having jurisdiction.

B. Die-cast aluminum housing and canopy.

C. Anodized aluminum housing with injection molded, high impact, clear acrylic panel edgelit.

D. Universal snap-out directional arrows as required.

E. Single and double face housing as required.

F. Mounting components for top, wall (back), or end mounting as shown on documents.

G. Internally Lighted Signs:
1. Lamps for AC Operation: White, light-emitting diodes, 70,000 hours minimum of rated lamp life.

H. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
1. Battery: Sealed, maintenance-free, nickel-cadmium type with special warranty. Battery to deliver 90 minute minimum capacity to fixture.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

2.4 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Minimum operating time of 90 minutes under full rated wattage.

C. Self-diagnostic technology.

D. Emergency Luminaires:

1. Emergency Luminaires: As indicated on Luminaire Schedule with the following additional features:
   a. Operating at nominal voltage of 120 V ac or 277 V ac: 6 V dc or 12 V dc.
   b. Internal emergency power unit self-contained.
   c. Remote mounted emergency power unit.
   d. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.
   e. UL 94 flame rating.
   f. All emergency fixtures shall be provided with a remote test switch and charge indicator module. Install device in a single gang back box, flush in ceiling tile, near emergency luminaire.
      1. Exception – Remote test switch/indicator lamp will not be required if the luminaire is provided with an integral test switch and lamp visible from below.

E. Stand-alone Emergency Lighting Unit:
1. Emergency Lighting Unit: As indicated on Luminaire Schedule.
2. Operating at nominal voltage of 120 V ac or 277 V ac: 6 V dc or 12 V dc.
3. Wall mount type with universal junction box adaptor.
4. UV stable thermoplastic housing for interior dry locations.
5. Aluminum housing for damp and wet location.
6. Two lamp heads as indicated on plans.
7. Internal emergency power unit.

2.5 LED SOURCES

A. LEDs to meet LM-80 performance for 50,000 hours

B. High efficiency driver

C. Standard full range dimming on troffers.

D. 5-year warranty of entire fixture including fixture construction and LED light engine driver.

E. LED lamp minimum CRI of 82

F. Fixture tested in accordance with IESNA LM-79.

2.8 FIXTURE SUPPORT COMPONENTS

G. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

H. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

I. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

J. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated, [12 gage].

K. Wires For Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

L. Rod Hangers: 3/16-inch- minimum diameter, cadmium-plated, threaded steel rod.

M. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.9 SOURCE QUALITY CONTROL

A. Provide services of a qualified, independent testing and inspecting agency to factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

B. Factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixtures: Set level, plumb, and square with ceilings and walls.

B. Support for Fixtures in or on Grid-Type Suspended Ceilings: Complete all of the following:
   1. Install a minimum of two support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3 and be supported by building steel (not ceiling system grid supports).
   2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

C. Suspended Fixture Support: As follows:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
   4. Continuous Rows: Suspend from cable.

D. Adjust aimable fixtures to provide required light intensities.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Verify normal operation of each fixture after installation.

C. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to battery power source and retransfer to normal.

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

E. Corroded Fixtures: During warranty period, replace fixtures that show any signs of corrosion.

END OF SECTION 265100

SECTION 270000 – COMMUNICATIONS INSTALLATION OVERVIEW

PART 1 - INSTALLATION OVERVIEW

1.1 SUMMARY

A. This project encompasses the installation of high capacity cabling backbone and associated hardware to support high-bandwidth communications.

1.2 THE COMPONENTS ASSOCIATED WITH THIS PROJECT ARE:

A. Conduit and Wiremold will be used to provide a protected pathway for all cables routed or installed in an exposed environment. The pathways for this project are included in the Division 26000 series of specifications.

B. CAT6, twisted pair cabling will be home run between each telephone/data drop location to the nearest existing telecom closet (TC).

1.3 RELATED SECTIONS

A. Drawings and general provisions of contract, including General and Supplementary conditions and Division 1 Specifications sections, apply to work in this section.

PART 2 - INSTALLATION PROCESS

2.1 INSTALLATION OF CONDUIT AND WIREMOLD

A. Unless otherwise stated on drawings, Electrical Contractor under Division 26 of this specification is to provide and install conduit and/or Wiremold in all situations where cabling exits ceiling cavities. All proposed cable routes and drop locations are approximate and should be verified by the contractor. Cable lengths indicated are approximate. It is the contractor responsibility to verify cable distances prior to cutting and routing of cables. It is the contractor responsibility to verify locations and quantities of drops.

B. All vertical cable runs between floors will be routed in conduit unless installed in a designated wiring closet, existing ceiling cavity, or specified differently. Vertical conduit runs shall be floor to ceiling or terminate in drop ceiling cavities. In all locations, penetration into the corridor ceiling cavities will be continuous and require the replacement of fire stop materials.

C. All core drills that are required shall be provided by the electrical contractor, unless otherwise noted. It is the responsibility of the contractor to verify locations with school officials prior to drilling and to fire stop in accordance with local and state codes.

PART 3 - EXECUTION

3.1 CABLING

A. All cables shall be routed in accordance with state and local codes and regulations. All cables installed and terminated shall follow the guidelines set forth by the manufacturer.
   1. When routing cables through ceiling cavities all cables shall be supported by bridal rings or j-hooks in a bundled manor and shall not be supported or rest on drop ceiling components. Cables shall be neatly swept and bundled. The maximum allowable cable sag between supports will be 6 inches as measured vertically. All cable will be run to

deck height while in ceiling cavities and fastened to roof supports or the bottom of the deck.

B. Drop locations
   1. Drop locations and types are as specified on the associated drawings. All locations are approximate and should be verified with district personnel prior to implementation.

3.2 LABELING

A. All cables are to be labeled at both the origination and termination locations using as specified a permanent alpha numeric cabling system. Cables shall be labeled at all junction points where a single continuous cable is not used, such as in a splice panel or Demarc.

B. Each faceplate shall have identification, which includes the cable number, and drop number if more than one of the same type of drop is installed in the room.

C. Testing
   1. CAT6 cables will be tested as per manufacturers' criteria, EIA/TIA and test specifications identified in this design.

PART 4 - COMPLETION

4.1 PROJECT COMPLETION

A. All documentation will be completed as specified. All cabling will be neat and secure.

B. Passing of data from each drop location will be done as specified, in conjunction with Owner. Refer to testing in the general specification section.

C. All facilities such as walls, ceilings etc., shall be restored to as found or better condition. All fire barriers breached shall be restored / sealed as to local, state and federal codes.

D. The removal of any construction or installation debris as a result of this project.

E. The Owner is to be consulted on any alterations of wiring closets, riser locations, and drop locations as required. Should conflicts between this design and the actual install or should any unforeseen circumstance occur during installation the contractor shall consult immediately with an authorized agent of the Owner.

END OF SECTION 270000

SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. UTP cabling.
2. Coaxial cable.
3. Optical Fiber System
4. Equipment racks and cable management
5. Multiuser telecommunications outlet assemblies.
6. Cable connecting hardware, patch panels, and cross-connects.
7. Telecommunications outlet/connectors.
8. Cabling system identification products.
9. Cable management system.
10. UPS

1.3 SCOPE OF WORK

A. This document describes the products and execution requirements relating to furnishing and installing Telecommunications Cabling for the horizontal cabling comprised of Copper and Optical Fiber Cabling, and support systems are covered under this document
1. Install a structured cabling system that will be able to support interconnections to active telecommunications equipment for voice and data applications in a multi vendor, multi product environment. The structured cabling system should adhere to ANSI/TIA/EIA standards with respect to pathways, distribution, administration, and grounding of the system. The structured cabling system to be installed should also follow the guidelines spelled out in this specification in accordance to local codes and regulations
2. Voice/Data: Each Standard data and/or telephone/data drop shown on associated drawings will consist of one data (RJ45) termination that will be used for data applications using blue CAT 6 cables.
3. Data Outlets for Wireless Access equipment: For each location shown, install one Category 6 UTP cables from the existing building data closet to the associated outlet. Install cable system from end to end (no splices). Terminate each cable on RJ45 jack in a single gang faceplate. Cabling shall consist of 4 pair Category 6 UTP cable, plenum rated and have orange jacket. Provide (1) orange patch cord at closet for each cable.
4. Cabling for CCTV cameras shall consist of 4 pair Category 6 UTP cable, plenum rated and have green jacket. Provide (1) green patch cord at closet.
5. Cabling for Security system components shall consist of 4 pair Category 6 UTP cable, plenum rated and have red jacket. Provide (1) red patch cord at closet
6. Install, terminate, test, and guarantee each drop according to customer all applicable standards and customer preferences
7. Horizontal cables will be rated Cat 6 in performance rated to connector outlets at the work area. Cables will home run back to associated data closets as indicated on drawings. Data will terminate on Cat 6 rated jacks to populate new modular 48 port patch panel(s).

8. All communication, wireless access point and security camera drops will be located as identified on the project electrical drawings.
9. New 12 strand single mode optical fiber shall be installed between the lower level data room and new IT Closet. All rack mounted fiber switches shall be provided by the owner. Contractor shall provide fiber, termination cabinets, type LC connectors and all associated materials for a complete operational system. Adequate spare fiber lengths shall be provided between termination cabinet and owner provided fiber switches for final terminations.
10. All cables and related terminations, support and grounding hardware shall be furnished, installed, wired, tested, labeled, and documented by the Telecommunications contractor as detailed in this document.
11. Product specifications, general design considerations, and installation guidelines are provided in this document. Quantities of telecommunications outlets, typical installation details, cable routing and outlet types will be provided as an attachment to this document. If the bid documents are in conflict, formal clarification shall be obtained from in the form of Question Clarification Request. The successful vendor shall meet or exceed all requirements for the cable system described in this document.

1.4 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. LAN: Local area network.

G. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.

H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

I. RCDD: Registered Communications Distribution Designer.

J. UTP: Unshielded twisted pair.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For coaxial cable, include the following installation data for each type used:
   a. Nominal OD.
   b. Minimum bending radius.

c. Maximum pulling tension.

B. Shop Drawings:
1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:
   a. Cross-connects.
   b. Patch panels.
   c. Patch cords.
5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer**,** qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports. Certification with approved Manufacturer to provide 25 year system warranty.

C. Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.9 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. Patch-Panel Units: One of each type.
2. Connecting Blocks: One of each type.
3. Device Plates: One of each type.
4. Multiuser Telecommunications Outlet Assemblies: One of each type.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

3. Testing Supervisor: Certified with a Manufacturer providing warranty and trained by approved tester Manufacturer.

B. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
1. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight.
2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.
1. TIA/EIA-568-C.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft. and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
1. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect. All cable lengths shall be measured prior to cutting or installation of any cable. The contractor shall notify the engineer of any cable lengths over 295’ prior to the cutting and installation of any cabling, cabling support hardware, and cable terminations.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-C.1 when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

D. Grounding: Comply with J-STD-607-A.

2.3 UTP CABLE

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide by Berk-Tek; Nexans LANmark 1000 Company or approved equivalent.

C. Description:
1. Category 6, 100-ohm, 4-pair UTP plenum rated cable with thermoplastic jacket for Voice and Data associated cabling. Cable shall be Berk-Tek; Nexans LANmark 1000 4-pr Cable.
   a. Comply with ICEA S-90-661 for mechanical properties.
   b. Comply with TIA/EIA-568-C.1 for performance specifications.
   c. Comply with TIA/EIA-568-C.2, Category 6 (Voice/Data)
   d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      1) Communications, Plenum Rated: Type CMP, complying with NFPA 262.

D. Color Designation: Data cables shall be blue in color.

2.4 UTP CABLE HARDWARE

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide by Panduit.

C. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

D. Angled Category 6 Patch Panels: Panduit #CPPA48HDWBLY, black , 48-port.
1. Angled patch panels shall have vertical fingered wire managers for Hi-density applications. Horizontal wire managers may not be necessary.

E. Jacks and Jack Assemblies: Panduit CJ Mini-Com series jacks, Category 6/10GbE, A-wired, 2-pack. White Color.

F. Patch Cords: Berk-Tek LANmark 1000 or approved equivalent Factory-made, four-pair cables in quantity and lengths as required in field; terminated with eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification

G. Patch cords shall be provided for standard voice/data drops where shown on drawings. Verify exact patch cord length with owner prior to installation. Patch cords for data receptacles to be blue. Patch cords for wireless access point cabling to be orange.

H. 12” patch cords with green jacket shall be provided for each camera where shown on drawings.

I. Final lengths of all patch cords will be determined in field. Length will be dependent upon distance between switch and patch panel on existing data rack using proper mounting procedures for neat workmanlike installation.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568B.

B. Workstation Outlets: Panduit CJ 688TGIW mini-com module. Ivory in color.
   1. Two port-connector assemblies mounted in single gang faceplate.
   2. Faceplates: Panduit Mini-Com Classic Series, Ivory
   3. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
      a. Flush mounting jacks, positioning the cord at a 45-degree angle.
   4. Legend: Machine printed, in the field, using adhesive-tape label.
   5. Labels shall be placed with a Normal or Arial font with the highest visibility for the address typed.
      a. Labels shall use Black lettering on a White background.
      b. The top label of the faceplate shall be the location identifier consisting of a 3-digit geographic identifier and building location followed by the floor number and wing.
      c. The bottom label of the faceplate shall be the Telecomm Room/IDF/MDF location of where the faceplate cables terminate.
      d. The label beside each jack insert of the faceplate shall indicate the individual workstation cable.

2.6 EQUIPMENT RACKS

A. Panduit R2P 19” Black, 2-post rack.
   1. 2-post rack layout shall consist of the following. (equipment quantities to be adjusted based on final rack quantity within room):
      a. Panduit R2P, black 2-post rack
      b. Panduit CMR4PWF, waterfall for the front-top of the rack
      c. Panduit PR2VSD06 6-inch dual-sided vertical manager
      d. Panduit PREP, vertical end cap panels
      e. Panduit PR2VSD08 8-inch dual-sided vertical manager
      f. Panduit PRSP5, rear slack spool, 5”
      g. Panduit PRSP7, front slack spool, 7”
      h. Power plug strip
      i. Panduit ground bar with a minimum of #6 THHN green bonding wire between bar and equipment rack.

2.7 OPTICAL FIBER CABLE

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide by Corning MIC-DX tight buffered armored cable

C. Description: 12-Strand Single mode, 50/125-micrometer, Interlocking Armored High Density, Plenum Rated indoor/outdoor, nonconductive**,** optical fiber cable. Aqua color outer jacket.
   1. Comply with ICEA S-83-596 for mechanical properties.
   2. Comply with TIA/EIA-568-C.3 for performance specifications.
   3. Comply with TIA-492AAAB for detailed specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
      a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.

5. Conductive cable shall be steel armored type.
6. Maximum Attenuation: 3.0 dB/km at 850 nm; 1.0 dB/km at 1300 nm.
7. Minimum Modal Bandwidth: 2000 MHz-km at 850 nm.

D. Jacket:
1. Interlocking Armored outer jacket.
2. Jacket Color: Aqua for 50/125-micrometer cable.
3. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
4. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.8 OPTICAL FIBER CABLE HARDWARE

A. The Fiber Optic is Corning Fiber Optic Solution.

B. Basis-of-Design Product: Subject to compliance with requirements, provide by Corning Cable systems, Type MIC DX Armored Cable.

C. Fiber connectors shall be LC Type Unicam terminations.
1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

D. Patch Cords:
1. Corning Singlemode SMF28e, LC-LC, 3-meter (Yellow)

E. Fiber Optic Panels
1. Corning #CCH-CP24-A9

F. Fiber Optic Shelves
1. Corning PCH Series

G. Cable Connecting Hardware:
1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-C.3.
2. Quick-connect, simplex and duplex, Type LC connectors. Insertion loss not more than 0.75 dB.

2.9 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Rack-mountable battery back-up

B. 1500VA power capacity

C. AC 120v

D. 3-year warranty

E. APC XS-1500

2.10 GROUNDING

A. Each telecommunications room shall be provided with a telecommunications ground bus bar (TGB). The TMGB shall be connected to the building electrical entrance grounding facility. The intent of this system is to provide a grounding system that is equal in potential to the building electrical ground system. Therefore, ground loop current potential is minimized between telecommunications equipment and the electrical system to which it is attached

B. All racks, metallic backboards, cable sheaths, metallic strength members, splice cases, cable trays, etc. entering or residing in the TR or ER shall be grounded to the respective TGB using a minimum #6 AWG stranded copper bonding conductor and compression connectors

C. All wires used for telecommunications grounding purposes shall be identified with a green insulation. Non-insulated wires shall be identified at each termination point with a wrap of green tape. All cables and bus bars shall be identified and labeled in accordance with the System Documentation Section of this specification

D. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

E. Comply with J-STD-607-A.

2.11 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.12 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-C.1.

C. Factory test UTP cables according to TIA/EIA-568-C.2.

D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-C.3.

E. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

F. Cable will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.

B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures:
   1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
   2. Install lacing bars and distribution spools.
   3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   1. Comply with TIA/EIA-568-C.1.
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. MUTOA shall not be used as a cross-connect point.
   5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
      a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      b. Locate consolidation points for UTP at least 49 feet from communications equipment room.
   6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
   9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
   10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
   12. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
   13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
   1. Comply with TIA/EIA-568-C.2.
   2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:
   1. Comply with TIA/EIA-568-C.3.
   2. Cable may be terminated on connecting hardware that is rack mounted.

E. Open-Cable Installation:
   1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
   3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:
   1. Install plenum-rated cable only.
   2. Install cabling after the flooring system has been installed in raised floor areas.
   3. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA-569-C for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.3 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: 1.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.

G. Cable and Wire Identification:
1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified 3rd Party testing agency currently certified by BICSI as an RCDD to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-C.1.
   2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
   3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   5. Optical Fiber Cable Tests:
      a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Link End-to-End Attenuation Tests:
         1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
         2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-C.1.
   6. UTP Performance Tests:
      a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-C.1 and TIA/EIA-568-C.2:
         1) Wire map.
         2) Length (physical vs. electrical, and length requirements).
         3) Insertion loss.
         4) Near-end crosstalk (NEXT) loss.
         5) Power sum near-end crosstalk (PSNEXT) loss.
         6) Equal-level far-end crosstalk (ELFEXT).
         7) Power sum equal-level far-end crosstalk (PSELFEXT).
         8) Return loss.
         9) Propagation delay.
         10) Delay skew.

7. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-C.3.
8. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.
    a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
    b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

D. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets

END OF SECTION 271500

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SECTION 280153 - CABLING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. RS-232 cabling.
2. RS-485 cabling.
3. Fire alarm wire and cable.

1.2 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

PART 2 - PRODUCTS

2.1 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.
1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.2 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM[or CMG].
1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.

4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.3 FIRE ALARM WIRE AND CABLE

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. Comtran Corporation.
2. Draka Cableteq USA.
3. Genesis Cable Products; Honeywell International, Inc.
4. Rockbestos-Suprenant Cable Corp.
5. West Penn Wire; a brand of Belden Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

END OF SECTION 280153

SECTION 284600 – ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes an upgrade/replacement and expansion to the existing Simplex fire alarm system in the Heritage Middle School Building at Newburgh Enlarged City School District.

B. This Section covers fire alarm systems, including initiating devices, notification appliances, controls, and supervisory devices.

C. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.

D. The Fire Alarm System shall consist of all necessary hardware equipment and software programming to perform the following functions:
   1. Fire alarm system detection and notification operations.
   2. Control and monitoring of elevators, smoke control equipment, door hold-open devices, fire suppression systems, emergency power systems, and other equipment as indicated in the drawings and specifications.

1.2 SCOPE OF WORK

A. The existing addressable fire alarm system will be upgraded to an intelligent reporting, microprocessor-controlled fire detection and notification system in accordance with the specifications and as indicated on associated electrical drawings.

B. The existing Simplex 4020 fire alarm control cabinet will physically stay in the same location. An additional 3 bay cabinet will be added and shall be located adjacent to the panel. Communication cabling will be added between the two units.

C. Equipment to support a voice evacuation system will be added.

D. Some equipment will be relocated from the existing panel to the new cabinet and new equipment added in both cabinets.

E. Existing field devices, relay contacts, and associated cabling/conduit will continue in use.

F. Existing annunciator panel will be replaced with new compatible annunciator and cabling will be replaced and added as required.

G. Existing devices in the cafeteria renovation area will be demolished and programming completed at the panel to indicate their removal.

H. Additional initiating and notification devices as well as cabling/conduit will be added throughout.

1.3 ACCEPTABLE EQUIPMENT AND SERVICE PROVIDERS

A. Manufacturers: The equipment and service described in this specification are those supplied and supported by SimplexGrinnell and represent the base bid for the equipment.
   1. Subject to compliance with the requirements of this specification.
      a. SimplexGrinnell

B. Being listed as an acceptable Manufacturer in no way relieves obligation to provide all equipment and features in accordance with these specifications.

C. Alternate products must be submitted to the Engineer a minimum of two weeks prior to bid for approval. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.

D. The equipment and service provider shall be a nationally recognized company specializing in fire alarm and detection systems. This provider shall employ factory trained and NICET Level II certified technicians, and shall maintain a service organization within 50 miles of this project location. The equipment and service provider shall have a minimum of 10 years experience in the fire protective signaling systems industry.

E. Johnson Controls (Simplex Grinnell) contact information
Brad Wilder, Johnson Controls
brad.wilder@jci.com

1.4 DEFINITIONS

A. ADA: Americans with Disabilities Act

B. AHJ: Authority Having Jurisdiction

C. ANSI: American National Standards Institute

D. ASME: American Society of Mechanical Engineers

E. FACU: Fire Alarm Control Unit

F. FM: Factory Mutual

G. IBC: International Building Code

H. ICC: International Code Council

I. IDC: Initiating Device Circuit

J. IEEE: Institute of Electrical and Electronic Engineers

K. IFC: International Fire Code

L. IMC: International Mechanical Code

M. IRI: Industrial Risk Insurers

N. LED: Light-emitting diode.

O. NAC: Notification Appliance Circuit

P. NFPA: National Fire Protection Association

Q. NICET: National Institute for Certification in Engineering Technologies.

R. RAC: Releasing Appliance Circuit

S. SLC: Signaling Line Circuit

T. UL: Underwriters Laboratories

1.5 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

B. The work covered by this section is to be coordinated with related work as specified elsewhere in the Division 26 and 28 specifications.

C. The system and all associated operations shall be in accordance with the following:
1. Requirements of the following Model Building Code: BOCA, SBCCI, UBC, IBC, NFPA 5000 latest applicable Edition
2. Requirements of the following Model Fire Code: BOCA, SBCCI, UFC, IFC, NFPA 1 latest applicable Edition
3. Requirements of the following Model Mechanical Code: BOCA, SBCCI, UMC, IMC latest applicable Edition
4. NFPA 72, National Fire Alarm Code, latest applicable Edition
5. NFPA 70, National Electrical Code, latest applicable Edition
6. NFPA 101, Life Safety Code, latest applicable Edition
7. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems, latest applicable Edition
8. ANSI/ASME A17.1 / CSA B44, Safety Code for Elevators and Escalators, latest applicable Edition
9. ICC/ANSI A117.1 Accessible and Useable Buildings and Facilities, latest applicable Edition
10. Local Jurisdictional Adopted Codes and Standards
11. ADA Accessibility Guidelines

1.6 SYSTEM DESCRIPTION

A. General: Provide a complete addressable, microprocessor-based fire alarm system with initiating devices, notification appliances, and monitoring and control devices as indicated on the drawings and as specified herein.

B. Elevator Recall initiation - Elevator recall shall be initiated only by one of, the following alarm-initiating devices:
1. Elevator lobby detectors except the lobby detector on the designated floor.
2. Smoke/heat detector in elevator machine room.
3. Smoke/heat detectors in elevator hoistway.

Elevator controller shall be programmed to move the car(s) to the alternate recall floor if lobby detectors located on the designated recall floors are activated.

C. Power Requirements
1. The control unit shall receive AC power via a dedicated power circuit.
2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal AC power in a normal supervisory mode for a period of 24 hours with 15 minutes of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.
3. All circuits requiring system-operating power shall be 24 VDC nominal voltage and shall be individually fused at the control unit.
4. The incoming power to the system shall be supervised so that any power failure will be indicated at the control unit. A green "power on" LED shall be displayed continuously at the user interface while incoming power is present.
5. The system batteries shall be supervised so that a low battery or a depleted battery condition, or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type.

6. The system shall support NAC Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control.
7. The system shall support 100% of addressable devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.
8. Loss of primary power shall sound a trouble signal at the FACP. FACP shall indicate when the system is operating on an alternate power supply.

D. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary.
1. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation.
2. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory.
3. Panels shall be capable of full system operation during new site specific configuration download, master exec downloads, and slave exec downloads.
4. Remote panel site-specific software and executive firmware downloads shall be capable of being performed over proprietary fire alarm network communications and via TCP/IP Ethernet network communications. Ethernet access to any fire alarm panel shall be capable of providing access only to authenticated users through a cryptographically authenticated and secure SSL tunnel.
5. Panels shall automatically store all program changes to the panel's non-volatile memory each time a new program is downloaded. Panels shall be capable of storing the active site-specific configuration program and no less than 9 previous revisions in reserve. A compare utility program shall also be available to authorized users to compare any two of the saved programs. The compare utility shall provide a deviation report highlighting the changes between the two compared programs.
6. Panels shall provide electronic file storage with a means to retrieve a record copy of the site-specific software and up to 9 previous revisions. Sufficient file storage shall be provided for other related system documentation such as record drawings, record of completion, owner's manuals, testing and maintenance records, etc.
7. The media used to store the record copy of site-specific software and other related system documentation shall be electrically supervised. If the media is removed a trouble shall be reported on the fire alarm control panel.

E. History Logs: The system shall provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.

F. Recording of Events: The system shall be capable of recording all alarm, supervisory, and trouble events by means of system printer. The printout shall include the type of signal (alarm, supervisory, or trouble) the device identification, date and time of the occurrence. The printout shall differentiate alarm signals from all other printed indications.

G. Wiring/Signal Transmission:
1. Transmission shall be hard-wired using separate individual circuits for each zone of alarm operation, as required or addressable signal transmission, dedicated to fire alarm service only.
2. System connections for initiating device circuits shall be Class B, Style D, signaling line circuits shall be Class B, Style 4 and notification appliance circuits shall be Class B, Style Y.

3. Circuit Supervision: Circuit faults shall be indicated by a trouble signal at the FACP. Provide a distinctive indicating audible tone and alphanumeric annunciation.

H. Supplemental Notification and Remote User Access (Fire Panel Internet Interface)
1. Fire Alarm Control Panel (FACP) shall provide the necessary hardware to provide supplemental notification and remote user access to the FACP using Ethernet and TCP/IP communications protocol compatible with IEEE Standard 802.3.
2. A standard RJ-45 Ethernet connection shall connect to the owners Ethernet network. Provisions for that connection must be provided at each fire alarm control panel as part of the contract.
3. The means of providing supplemental email and SMS text messaging notification shall be agency listed for specific interfaces and for the purpose described in this section. The use of non-listed external third party products and interfaces is not acceptable.
4. The fire panel internet interface shall be capable of sending automated notification of discrete system events via email and SMS text messaging to up to 50 individual user accounts and via email to up to 5 distribution list.
5. Each user account and distribution list shall be capable of being configurable for the specific type of events to be received. Each account shall be configurable to receive notification upon any combination of the following types of events:
   a. Fire Alarm,
   b. Priority 2,
   c. Supervisory,
   d. Trouble,
   e. Custom Action Messages,
   f. Fire Panel Internet Interface Security Violations
6. Each user account and distribution list shall be capable of being configurable for the specific content to be received. Each account shall be configurable to receive any combination of the following message content:
   a. Summary,
   b. Event Information,
   c. Message,
   d. Emergency Contacts,
   e. Host Fire Alarm Control Panel Information
7. Each user account and distribution list shall be capable of being configurable for the type of Fire Alarm Control Panel Logs and Reports to be received. Each account shall be configurable to receive any combination of the following Logs and Reports via email:
   a. Alarm Log,
   b. Trouble Log,
   c. Analog Sensor Status Report,
   d. Analog Sensor Service Report,
   e. Almost Dirty, Dirty and Excessively Dirty Sensor Report,
   f. CO Analog Sensor Service Report,
   g. Addressable Appliance Candela Report,
   h. Addressable Appliance Status Report
8. Each user account and distribution list shall be capable of receiving email distribution of Fire Alarm Control Panel Logs and Reports On-Demand or automatically on a Pre-Determined schedule. Receipt of Logs and Reports shall be capable of being scheduled as follows:
   a. Weekly, or
   b. Bi-weekly, or
   c. Monthly

9. The Fire Alarm Control Panel Logs and Reports shall be sent in CSV file format which can be imported into common database applications for viewing, sorting, and customization.
    a. Each user account shall be capable of being configured to receive system events via email and/or SMS text messaging.
    b. Each distribution list shall be capable of supporting up to 20 email address recipients.
10. The means to provide email notification shall be compatible with SMTP mail servers, ISP email services, and Internet email services. Communication with the email server shall be verified at selectable intervals of 5 to 30 minutes.
11. Email operation shall be capable of being disabled for service by the system administrator.
12. An email log shall be accessible to authorized users. The email log shall display the 25 most recent email notifications sent.
13. The fire panel internet interface for supplemental notification and remote user access shall support:
    a. Secure HTTPS/SSL encrypted connections,
    b. Up to 50 individual password protected user accounts,
    c. Dynamic and Static IP addressing,
    d. IP Address Blocking,
    e. Restricted number of log-in attempts before lock-out configurable from 1 to 20,
    f. Lock-out duration after unsuccessful log-in attempts configurable from 0 to 24 hours,
    g. Email notification to Administrators of unsuccessful log-in attempts,
    h. Automatic lock-out reset upon a new event,
    i. Automatic inactivity logout configurable from 10 minutes to 24 hours,
    j. Firmware updates over ethernet,
    k. Set-up and configuration via Local Service Port or via Remote Services over LAN/WAN connection
14. Authorized users shall be capable of accessing the fire alarm panel using a compatible web browser (Internet Explorer 6.0 or higher) and a secure HTTPS/SSL encrypted connection.
15. The fire panel internet interface shall support concurrent connections for up to 5 users plus 1 administrator.
16. Authorized users with remote access shall be capable of:
    a. Viewing the fire panel internet interface web home page
        1) The fire panel internet interface home page shall display system status information and provide links to detailed status information and fire alarm panel reports and history logs
        2) The web browser on the user's computer shall automatically refresh system status information upon a new event
            i. Systems that require a manual refresh to acquire updated system status information shall not be accepted
    b. Viewing the fire alarm panel detailed card status information
    c. Viewing the fire alarm panel detailed point status information
    d. Viewing the fire alarm panel reports and history logs
    e. Viewing the fire panel internet interface email log
    f. Viewing system summary information
    g. Accessing Custom Hypertext Links
17. The fire panel internet interface home page shall support customization to display the following information:
    a. Customer Name and Address,
    b. Fire Panel Location or Building Name,
    c. Up to 10 Custom Hypertext Links with Text Descriptions

I. Remote Services Access:

1. Fire Alarm Control Panel (FACP) shall provide the necessary hardware to provide a remote service access feature using Ethernet and TCP/IP communications protocol compatible with IEEE Standard 802.3. The Remote Access feature shall provide automatic notification of system faults and remote diagnostics of system status for responding technicians prior to arrival on site.
2. A standard RJ-45 Ethernet connection shall connect to the owners Ethernet network. Provisions for that connection must be provided at each fire alarm control panel as part of the contract.
3. The Ethernet access feature shall be agency listed for specific interfaces and for the purpose described in this section. The use of non-listed external third party interfaces is not acceptable.
4. The internet remote access service function shall provide automated real time off-site reporting of discrete system events to a remote service support center with details of internal FACP fault conditions allowing a pre-site visit analysis of repair requirements.
5. Existing FACP controls shall be capable of retrofitting the Remote Service module as a plug-in upgrade feature.
6. The remote service network shall work on the customers Ethernet infrastructure and be Fire-Wall friendly for two-way communications for off-site reporting. The feature shall be compatible with existing proxy servers and firewalls shall not require any special changes or modifications.
7. The remote service system shall be able to connect to the remote service center without the need for a VPN account or similar tunnel.
8. The remote service system shall be a non-Windows based application to protect against conventional virus attacks.
9. The remote service system shall support a secure connection with strong encryption, 128 bit or better, and an optional secondary encryption method if required.
10. The remote service system shall be compatible with virtual LANS (VLAN).
11. The remote service system shall work on an outbound communication premise (panel calls home) in order to eliminate the possibility of any inbound connection into the network (from trusted or non-trusted sites).
12. The remote service system shall provide an audit trail of all events and service connections.
13. The Remote Service connection will provide access for panel software downloads and uploads for archiving job specific programs back at the enterprise server.
14. The supplier shall provide a service contract for the Remote Service program that provides the following requirements:
15. 24/7 recording of FACP service activity.
16. Off-site diagnostics by a technical specialist to provide repair and parts guidance to the service technician prior to a site visit.
17. Should a proposed system not have these features, the fire alarm vendor will make monthly site visits, during the warranty period, to check the system status and provide system diagnostics. The vendor will record sensitivity readings and smoke detector cleanliness for all devices.

J. Required Functions: The following are required system functions and operating features:

1. Priority of Signals: Fire alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second-, third-, and fourth-level priority, respectively. Signals of a higher-level priority take precedence over signals of lower priority even though the lower-priority condition occurred first. Annunciate all events regardless of priority or order received.

2. Noninterfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent addressable device activations.
3. Transmission to an approved Supervising Station: Automatically route alarm, supervisory, and trouble signals to an approved supervising station service provider, under another contract.
4. Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP and the remote annunciator, indicating the type of device, the operational state of the device (i.e. alarm, trouble or supervisory) and shall display the custom label associated with the device.
5. Selective Alarm: A system alarm shall include:
    a. Indication of alarm condition at the FACP and the annunciator(s).
    b. Identification of the device /zone that is the source of the alarm at the FACP and the annunciator(s).
    c. Operation of audible and visible notification appliances until silenced at FACP.
    d. Close all doors normally held open by magnetic door holders on all fire floors
    e. Unlocking designated doors.
    f. Shutting down supply and return fans when alarm is initiated.
    g. Closing smoke dampers on system when alarm is initiated.
    h. Initiation of smoke control sequence.
    i. Transmission of signal to the supervising station.
    j. Initiation of elevator Phase I functions (recall, shunt trip, illumination of indicator in cab, etc.) in accordance with ANSI/ASME A17.1 / CSA B44, Safety Code for Elevators and Escalators, when specified detectors or sensors are activated, as appropriate.
6. Supervisory Operations: Upon activation of a supervisory device such as a tamper switch, the system shall operate as follows:
    a. Activate the system supervisory service audible signal and illuminate the LED at the control unit and the remote annunciator.
    b. Pressing the Supervisory Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.
    c. Record the event in the FACP historical log.
    d. Transmission of supervisory signal to the supervising station.
    e. Restoring the condition shall cause the Supervisory LED to clear and restore the system to normal.
7. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible and visible alarm signals shall cease operation.
8. Priority Two Operations: Upon activation of a priority two condition such as CO gas detection the system shall operate as follows:
    a. Activate the system priority two audible signal and illuminate the LED at the control unit and the remote annunciator.
    b. Pressing the Priority 2 Acknowledge Key will silence the audible signal while maintaining the Priority 2 LED "on" indicating off-normal condition.
    c. Record the event in the FACP historical log.
    d. Transmission of priority two signal to the supervising station.
    e. Restoring the condition shall cause the Priority 2 LED to clear and restore the system to normal.
9. System Reset

a. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarming the system. The display message shall indicate "ALARM PRESENT, SYSTEM RESET ABORTED."
b. Should an alarm condition continue, the system will remain in an alarmed state.

10. A manual evacuation (drill) switch shall be provided to operate the notification appliances without causing other control circuits to be activated.
11. WALKTEST: The system shall have the capacity of 8 programmable passcode protected one person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one person test" program at the control unit shall activate the "One Person Testing" mode of the system as follows:
    a. The city circuit connection and any suppression release circuits shall be bypassed for the testing group.
    b. Control relay functions associated with one of the 8 testing groups shall be bypassed.
    c. The control unit shall indicate a trouble condition.
    d. The alarm activation of any initiating device in the testing group shall cause the audible notification appliances assigned only to that group to sound a code to identify the device or zone.
    e. The unit shall automatically reset itself after signaling is complete.
    f. Any opening of an initiating device or notification appliance circuit wiring shall cause the audible signals to sound for 4 seconds indicating the trouble condition.
12. Install Mode: The system shall provide the capability to group all non-commissioned points and devices into a single "Install Mode" trouble condition allowing an operator to clearly identify event activations from commissioned points and devices in occupied areas.
    a. It shall be possible to individually remove points from Install Mode as required for phased system commissioning.
    b. It shall be possible to retrieve an Install Mode report listing that includes a list of all points assigned to the Install Mode. Panels not having an install mode shall be reprogrammed to remove any non-commissioned points and devices.
    c. Failure to provide this feature will require the vendor to provide the required NFPA testing immediately following each program change during construction.
13. Module Distribution:
    a. The fire alarm control panel shall be capable of allowing remote location of the following modules; interface of such modules shall be through a Style 4 (Class B) supervised serial communications channel (SLC):
        1) Initiating Device Circuits
        2) Notification Appliance Circuits
        3) Auxiliary Control Circuits
        4) Graphic Annunciator LED/Switch Control Modules
            i. In systems with two or more Annunciators and/or Command Centers, each Annunciator/Command Center shall be programmable to allow multiple Annunciators/Command Centers to have equal operation priority or to allow hierarchal priority control to be assigned to individual Annunciator/Command Center locations.
        5) Initiating Device Signaling Line Circuits
        6) Notification Appliance Signaling Line Circuits
        7) Power Supplies

14. Service Gateway: A Service Gateway software application shall be provided that allows an authorized service person to remotely query panel status during testing, commissioning, and service without the need to return to the panel using standard email or instant messaging tools. For systems without a service gateway application the service provider shall provide a minimum of two technicians for any system testing or commissioning.
15. Building Automation and Control Network (BACnet) Integration
    a. The fire alarm control unit shall be capable of providing a one-way communications interface between the fire alarm control unit and an industry-standard Building Automation and Control Network (BACnet) using ASHRAE® BACnet® IP (internet protocol) compliant with ANSI/ASHRAE Standard 135.
    b. The BACnet communications module shall be agency listed to UL Standard 864.
    c. The fire alarm control unit shall be capable of communicating up to 1000 status changes to the building automation system.
    d. MS/TP Master and MS/TP Slave data link layer options communicating at baud rates up to 76,800 bps shall be supported.
    e. The interface shall be capable of supporting ANSI X3.4, ISO 10656 (ICS-4), ISO 10656 (UCS-2), ISO 8859-1, or IBM/Microsoft DBCS character sets.
    f. A standard RJ-45 Ethernet connection to the Building Automation System Ethernet network shall be provided at the fire alarm control unit as part of the contract.
    g. Systems using relay interfaces shall not be accepted.

K. Analog Smoke Sensors:
1. Monitoring: FACP shall individually monitor sensors for calibration, sensitivity, and alarm condition, and shall individually adjust for sensitivity. The control unit shall determine the condition of each sensor by comparing the sensor value to the stored values.
2. Environmental Compensation: The FACP shall maintain a moving average of the sensor's smoke chamber value to automatically compensate for dust, dirt, and other conditions that could affect detection operations.
3. Programmable Sensitivity: Photoelectric Smoke Sensors shall have 7 selectable sensitivity levels ranging from 0.2% to 3.7%, programmed and monitored from the FACP.
4. Sensitivity Testing Reports: The FACP shall provide sensor reports that meet NFPA 72 calibrated test method requirements.
    a. Reports shall be capable of being printed for annual recording and logging of the calibration maintenance schedule.
    b. Where required, reports shall be accessible remotely through:
        1) A Fire Panel Internet Interface using Ethernet and TCP/IP communications protocol compatible with IEEE Standard 802.3. The Fire Panel Internet Interface shall be capable of automatically scheduling email reports to individual user accounts on a weekly, bi-weekly, or monthly schedule
        2) A PC Annunciator using an RS232-C connection to the FACP or a PC Annunciator Client using a TCP/IP communications protocol connection to the PC Annunciator server compatible with IEEE Standard 802.3.
5. The FACP shall automatically indicate when an individual sensor needs cleaning. The system shall provide a means to automatically indicate when a sensor requires cleaning. When a sensor's average value reaches a predetermined value, (3) progressive levels of reporting are provided. The first level shall indicate if a sensor is close to a trouble reporting condition and will be indicated on the FACP as "ALMOST DIRTY." This condition provides a means to alert maintenance staff of a sensor approaching dirty without creating a trouble in the system. If this indicator is ignored and the second level is reached, a "DIRTY SENSOR" condition shall be indicated at the FACP and subsequently a system

trouble is reported to the Supervising Station. The sensor base LED shall glow steady giving a visible indication at the sensor location. The "DIRTY SENSOR" condition shall not affect the sensitivity level required to alarm the sensor. If a "DIRTY SENSOR" is left unattended, and its average value increases to a third predetermined value, an "EXCESSIVELY DIRTY SENSOR" trouble condition shall be indicated at the control unit.

6. The FACP shall continuously perform an automatic self-test on each sensor that will check sensor electronics and ensure the accuracy of the values being transmitted. Any sensor that fails this test shall indicate a "SELF TEST ABNORMAL" trouble condition.
7. Multi-Sensors shall combine photoelectric smoke sensing and heat sensing technologies. An alarm shall be determined by either smoke detection, with selectable sensitivity from 0.2 to 3.7 %/ft obscuration; or heat detection, selectable as fixed temperature or fixed with selectable rate-of-rise; or based on an analysis of the combination of smoke and heat activity.
8. Programmable bases. It shall be possible to program relay and sounder bases to operate independently of their associated sensor.
9. Magnet test activation of smoke sensors shall be distinguished by its label and history log entry as being activated by a magnet.

L. Fire Suppression Monitoring:
1. Water flow: Activation of a water flow switch shall initiate general alarm operations.
2. Sprinkler valve tamper switch: The activation of any valve tamper switch shall activate system supervisory operations.
3. WSO: Water flow switch and sprinkler valve tamper switch shall be capable of existing on the same initiating zone. Activation of either device shall distinctly report which device is in alarm on the initiating zone.

M. Audible Alarm Notification: By speakers in areas as indicated on drawings.

N. Addressable Notification Appliances (Applies only where addressable notification is provided):
1. Monitoring: The FACU shall monitor individual addressable notification appliances for status, condition, type of appliance, and configured appliance settings. A fault in any individual appliance shall automatically report a trouble condition on the FACU.
2. Individual Appliance Custom Label: Each addressable appliance shall have its own 40 character custom label to identify the location of the appliance and to aid in troubleshooting fault conditions.
3. Individual Appliance Information Display:
    a. The FACU shall be capable of calling up detailed information for each addressable appliance including the appliance location, status, condition, type of appliance, and configured appliance settings.
    b. Notification appliances that are not capable of communicating and reporting their individual location, status, condition, type of appliance, and configured appliance settings to the FACU shall not be accepted.
4. Programmable Appliance Settings:
    a. The selectable operation of each addressable notification appliance shall be capable of being configured by the FACU without having to replace or remove the appliance from the wall or ceiling.
        1) Programmable appliance settings for applicable addressable notification appliances shall include:
            i. Operation: General Evac, Alert, User Defined
            ii. Style: Indoor, UL Weatherproof, ULC Weatherproof

iii. Candela Selections: Indoor: 15, 30, 75, 110, 135, or 185 cd (per UL1971), UL Weatherproof: 15 or 75 cd (per UL1971), and 75 or 185 cd (per UL1638), ULC Weatherproof: 20, 30 or 75 cd (per ULCS526)

5. Programmable Notification Zones:
   a. Changing the notification zone assigned to a notification appliance shall be configurable by the FACU and shall not require additional circuits or wiring.
6. Other Emergency and Non-Emergency Notification:
   a. Where required, notification appliances for purposes not related to fire alarm shall be capable of:
      1) being connected to the same circuit as the fire alarm appliances, and
      2) being individually configured for their intended use without requiring additional circuits or wiring.
7. Addressable Notification Appliance Automated Self-Test:
   a. The fire alarm control unit shall be capable of performing an automated functional self-test of all self-test notification appliances and meet the requirements in NFPA 72, 2013 Edition, 14.2.8 Automated Testing and Table 14.4.3.2 testing requirements.
   b. Test results for each self-test notification appliance shall be stored in non-volatile memory at the fire alarm control unit.
   c. The fire alarm control unit shall be capable of running a functional automated test for all self-test notification appliances in a general alarm group or for all self-test appliances within a specific notification zone.
   d. The duration required to complete the automated functional test for all self-test notification appliances shall be accomplished in 2 minutes or less.
   e. The automated test results for all self-test notification appliances shall be available from the fire alarm control unit within 4 minutes from the start of the test.
   f. If any notification appliance fails its automated functional self-test an audible and visual trouble signal shall be annunciated at the fire alarm control unit.
   g. The self-test trouble signal shall be a latching trouble signal which requires manual restoration to normal.
8. Addressable Notification Appliance Reports:
   a. The fire alarm control unit shall maintain configuration and test data for each self-test addressable notification appliance.
   b. The fire alarm control unit shall be capable of generating configuration, self-test, and deficiency reports, that can be viewed through the fire alarm control unit user interface or printed via the fire alarm control unit service port.
      1) At minimum, the configuration report shall include the following information applicable for each addressable notification appliance:
         i. Point ID
         ii. Custom Label
         iii. Device Type
         iv. Candela Setting
      2) At minimum, the self-test report shall include the following information applicable for each self-test notification appliance:
         i. Point ID
         ii. Custom Label
         iii. Time and Date of last test
         iv. Pass / Fail results of last visual test
         v. Pass / Fail results of last audible test
   c. The fire alarm control unit shall also be capable of providing a deficiency report that includes a list of all self-test notification appliances that have failed self-test.

9. Magnet test: When the control unit is in diagnostic mode, the appliances shall be capable of being tested with a magnet. The magnet diagnostics shall:
   a. Pulse the appliance LED to indicate appliance address and briefly sound the individual speaker to confirm the audible appliance operation and briefly flash the individual strobe to confirm visible appliance operation.

1.7 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections.
   1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.
   2. Wiring diagrams from manufacturer.
   3. Wiring diagrams showing interconnection between new and existing panels and system components.
   4. Shop drawings showing system details including location of FACP, all devices, circuiting and details of graphic annunciators.
   5. System power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate in accordance with the prescribed backup time periods and under all voltage conditions per UL and NFPA standards.
   6. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location or use of IDC, SLC, NAC, relay, sensor, and auxiliary control circuits.
   7. Operating instructions for FACP.
   8. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations.
   9. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.
   10. Record of field tests of system.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: A factory authorized installer is to perform the work of this section.

B. Each and every item of the Fire Alarm System shall be listed under the appropriate category by Underwriters Laboratories, Inc. (UL), and shall bear the "UL" label.

1.9 MAINTENANCE SERVICE

A. Maintenance Service Contract: Provide maintenance of fire alarm systems and equipment for a period of 12 months, using factory-authorized service representatives.

B. Basic Services: Systematic, routine maintenance visits on a quarterly basis at times scheduled with the Owner. In addition, respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies.

C. Additional Services: Perform services within the above 12-month period not classified as routine maintenance or as warranty work when authorized in writing. Compensation for additional services must be agreed upon in writing prior to performing services.

D. Renewal of Maintenance Service Contract: No later than 60 days prior to the expiration of the maintenance services contract, deliver to the Owner a proposal to provide contract maintenance and repair services for an additional one-year term. Owner will be under no obligation to accept maintenance service contract renewal proposal.

PART 2 - PRODUCTS

2.1 ACCEPTABLE EQUIPMENT AND SERVICE PROVIDERS

A. Manufacturers: The equipment and service described in this specification are those supplied and supported by Tyco SimplexGrinnell (now Johnson Controls, "JCI") and represent the required equipment.
   1. Subject to compliance with the requirements of this specification, provide products by one of the following:
      a. Simplex-Fire, a Johnson Control Company – 4100ES

B. The equipment and service provider shall be a nationally recognized company specializing in fire alarm and detection systems. This provider shall employ factory trained and NICET Level III certified technicians and shall maintain a service organization within 50 miles of this project location. The equipment and service provider shall have a minimum of 10 years experience in the fire protective signaling systems industry. Shall have employees with the most recent 4100ES certification and provide documentation upon request.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
   1. Manual stations.
   2. Heat detectors.
   3. Smoke detectors.
   4. Duct smoke detectors.
   5. Verified automatic alarm operation of smoke detectors.
   6. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:
   1. Continuously operate alarm notification appliances.
   2. Identify alarm at fire-alarm control unit and remote annunciators.
   3. Transmit an alarm signal to the remote alarm receiving station.
   4. Unlock electric door locks in designated egress paths.
   5. Release fire and smoke doors held open by magnetic door holders.
   6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
   7. Recall elevators to primary or alternate recall floors.
   8. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
   1. Valve supervisory switch.
   2. Elevator shunt-trip supervision.

D. System trouble signal initiation shall be by one or more of the following devices and actions:
   1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal AC voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer where provided.

2.3 FIRE ALARM CONTROL PANEL

A. General: Comply with UL 864, "Control Units and Accessories for Fire Alarm Systems".

B. The following FACP hardware shall be provided: Johnson Controls 4100ES.
1. Power Limited base panel with red cabinet and door, 120 VAC input power.
2. 2500 point capacity where (1) point equals (1) monitor (input) or (1) control (output).
3. 2000 points of annunciation where one (1) point of annunciation equals:
   a. 1 LED driver output on a graphic driver or 1 switch input on a graphic switch input module.
   b. 1 LED on panel or 1 switch on panel.
4. From all battery charging circuits in the system provide battery voltage and ammeter readouts on the FACP LCD Display.
5. One Auxiliary electronically resettable fused 2A @24VDC Output, with programmable disconnect operation for 4-wire detector reset.
6. One Auxiliary Relay, SPDT 2A @32VDC, programmable as a trouble relay, either as normally energized or de-energized, or as an auxiliary control.
7. Three (3) Class B or A (Style Y/Z) Notification Appliance Circuits (NAC; rated 3A@24VDC, resistive).
8. Where required provide Intelligent Remote Battery Charger for charging up to 110Ah batteries.
9. Power Supplies with integral intelligent Notification Appliance Circuit Class B for system expansion.
10. Four (4) form "C" Auxiliary Relay Circuits (Form C contacts rated 2A @ 24VDC, resistive), operation is programmable for trouble, alarm, supervisory of other fire response functions. Relays shall be capable of switching up to ½ A @ 120VAC, inductive.
11. The FACP shall support up to (5) RS-232-C ports and one service port. All (5) RS-232 Ports shall be capable of two-way communications.
12. Remote Unit Interface: supervised serial communication channel for control and monitoring of remotely located annunciators and I/O panels.
13. Municipal City Circuit Connection with Disconnect switch, 24VDC Remote Station (reverse polarity), local energy, shunt master box, or a form "C" contact output.
14. Programmable DACT for either Common Event Reporting or per Point Reporting.
15. Fire Panel Internet Interface to provide supplemental notification and remote user access to the FACP using Ethernet and TCP/IP communications protocol compatible with IEEE Standard 802.3.

C. Cabinet: A Lockable three (3) Bay steel backbox. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If

more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures. Provide as noted in scope of work.

D. Alphanumeric Display and System Controls: Panel shall include an 80 character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.
   1. The system shall include the necessary hardware to provide expanded content, multi-line, operator interface displays. The expanded content multi-line displays shall be Quarter-VGA (QVGA) or larger and be capable of supporting a minimum of 854 standard ASCII characters to minimize or eliminate the levels of navigation required for access to information when responding to critical emergencies and abnormal system conditions. The QVGA operator interface shall provide operator prompts and six context sensitive soft-keys for intuitive operation.
      a. Expanded content, multi-line operator interfaces shall be capable of providing the following functions:
         1) Dual language operation with Instant-Switch language selection during runtime.
         2) Activity display choices for:
            i. First 8 Events.
            ii. First 5 Events and Most Recent Event (with first and most recent event time and date stamps).
            iii. First Event and Most Recent Event (with first and most recent event time and date stamps).
            iv. Scrollable List Display displays a scrollable list of active points for the event category (alarm, priority 2, supervisory, or trouble) selected. The position in this list will be the last acknowledged point (not flashing) at the top followed by the next 7 unacknowledged points (flashing).
            v. General Event Status (alarm, priority 2, supervisory, or trouble in system)
            vi. Site Plan
         3) Equal or hierarchal priority assignment. In systems with two or more operator interfaces, each operator interface shall be programmable to allow multiple operator interfaces to have equal operation priority or to allow hierarchal priority control to be assigned to individual operator interfaces (locations).
         4) Up to 50 custom point detail messages for providing additional point specific information in detailed point status screens.
         5) Bitmap file import for operator interface display of site plan and background watermark images. Site plan status icons shall indicate area status for highest priority active events.
      b. Expanded content, multi-line displays shall include the necessary hardware and software to provide Dual-Language operation[as indicated on the drawings and specifications].
         1) Language selection shall be via a switch on the operator interface panel. Operator interface panels shall support instant-language-switchover during runtime to allow the operator to toggle between languages each time the language selection switch is operated, without requiring complicated multi-step processes.
         2) Both one-byte and two-byte characters shall be supported.

E. Distributed Module Operation: FACP shall be capable of allowing remote location of the following modules; interface of such modules shall be through a Style 4 (Class B) supervised serial communications channel (SLC):

1. Addressable Signaling Line Circuits
2. Initiating Device Circuits
3. Notification Appliance Circuits
4. Auxiliary Control Circuits
5. Switch Control Modules
    a. In systems with two or more Annunciators and/or Command Centers, each Annunciator/Command Center shall be programmable to allow multiple Annunciators/Command Centers to have equal operation priority or to allow hierarchal priority control to be assigned to individual

2.4 ADDRESSABLE MANUAL PULL STATIONS

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

B. Description: Addressable double action type, red LEXAN. Station shall mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units. Station shall be pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit. Where double-action stations are provided, the mechanism shall require two actions to initiate an alarm.

C. Protective Shield: Where required, as indicated on the drawings, provide a tamperproof, clear LEXAN shield and red frame that easily fits over manual pull stations. When shield is lifted to gain access to the station, a battery powered piercing warning horn shall be activated. The horn shall be silenced by lowering and realigning the shield. The horn shall provide 85dB at 10 feet and shall be powered by a 9 VDC battery.

D. Johnson Controls 4099 Series

2.5 ADDRESSABLE ANALOG SMOKE SENSORS

A. General:

1. Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:
2. Factory Nameplate: Serial number and type identification.
3. Operating Voltage: 24 VDC, nominal.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.
5. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break-off plastic tab that can be removed to engage the head/base locking mechanism. Provide terminals in the fixed base for connection to building wiring. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit. Sensors shall include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACU. Sensor address shall be located in base to eliminate false addressing when replacing sensors. Integral Addressable Module shall be arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit. Each sensor base shall contain an integral visual-indicating LED that will flash to provide power-on status each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the sensor base LED shall be on steady. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base.][Quick Connect Arrangement: Photoelectric sensor and electronics in a single piece construction which shall twist-lock onto a mounting base that attaches to a standard electrical box. Provide terminals in the fixed base for connection to building wiring. Sensors shall include an internal communication transmitter and receiver in the sensor having a unique identification and capability for status reporting to the FACU. Integral Addressable Module shall be arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit. Each sensor shall contain an integral visual-indicating LED that will flash to provide power-on status each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the sensor LED shall be on steady. Sensor and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base.
6. Each sensor base shall contain a magnetically actuated test switch to provide for easy pre-certification alarm testing at the sensor location.
7. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.
8. Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit. Provide multiple levels of detection sensitivity for each sensor.
9. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct smoke sensor shall be provided by the FACU.
10. The sensor's electronics shall be immune from nuisance alarms caused by EMI and RFI. Removal of the sensor head for cleaning shall not require the setting of addresses.

11. Bases: CO Sensor, relay output, sounder and isolator bases shall be supported alternatives to the standard base.
12. Johnson Controls 4098 Series

B. Addressable Sensor Bases
1. Standard base - Twist lock addressable base with address selection DIP switch accessible from front with sensor removed. Integral red LED for power-on (pulsing), or alarm or trouble (steady on). Locking anti-tamper design mounts on standard outlet box.
2. Sensor Base with remote device connection - All standard base features with wired connection for either a Remote LED alarm indicator or remote relay (relay is unsupervised and requires separate 24VDC)
3. Supervised Relay Bases - All standard base features and shall be available in either a 4-Wire Sensor Base to use with remote or locally mounted relay; requires separate 24 VDC, or as a 2-Wire Sensor Base to use with remote or locally mounted relay; no separate power required. Supervised relay operation shall be programmable and shall be manually operated from control panel.
4. Sensor base with built-in electronic alarm sounder - All standard base features and piezoelectric sounder shall provide high output (88 dBA) with low current requirements (20 mA). Sounder shall be synchronized via SLC communications or by the NAC if NAC powered, sounder shall operation shall be programmable and shall be manually operated from control panel.
5. 520 Hz Sensor base with built-in electronic low frequency sounder - All standard base features and piezoelectric sounder shall provide a low frequency 520 Hz Square Wave (85 dBA) with nominal current requirements (115 mA). Sounder shall be synchronized via SLC communications or by the NAC if NAC powered, sounder operation shall be programmable and shall be manually operated from control panel.
    a. Emitted tone shall be a 520Hz Square Wave signal in compliance with the requirements of the 2010 edition of NFPA 72 for sleeping areas.
    b. The 520Hz Sounder base shall be listed to UL 268 and UL464, Audible Signal Appliances.
6. Johnson Controls 4098 Series

C. Duct Smoke Sensor: Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Duct housing shall include relay or relay driver as required for fan shutdown.
1. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct smoke sensor shall be provided by the FACP.
2. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable. Relay shall be mounted within 3 feet of HVAC control circuit.
3. Duct Housing shall provide a relay control trouble indicator Yellow LED.
4. Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.
5. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.
6. Duct Housing shall provide a magnetic test area and Red sensor status LED.
7. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
8. Each duct smoke sensor shall have a Remote Test Station with an alarm LED and test switch.

9. Where indicated provide a NEMA 4X weatherproof duct housing enclosure that shall provide for the circulation of conditioned air around the internally mounted addressable duct sensor housing to maintain the sensor housing at its rated temperature range. The housing shall be UL Listed to Standard 268A.
10. Johnson Controls 4098 Series

2.6 ADDRESSABLE HEAT SENSORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Thermal Sensor Combination type: Fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp; Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

C. Thermal sensor shall be of the epoxy encapsulated electronic design. It shall be thermistor-based, rate-compensated, self-restoring and shall not be affected by thermal lag. Selectable rate compensated, fixed temperature sensing with or without rate-of-rise operation.

D. Mounting: Twist-lock base interchangeable with smoke-sensor heads.

E. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

F. Sensor fixed temperature sensing shall be independent of rate-of-rise sensing and programmable to operate at 135-deg F or 155-deg F. Sensor rate-of-rise temperature detection shall be selectable at the FACU for either 15-deg F or 20-deg F per minute.

G. Sensor shall have the capability to be programmed as a utility monitoring device to monitor for temperature extremes in the range from 32-deg F to 155-deg F.

H. Unless otherwise indicated, sensors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for temperature by fire-alarm control unit.

I. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.

J. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).

K. Johnson Controls 4098 Series

2.7 ADDRESSABLE CO SENSOR

A. Addressable CO Sensor
1. The CO Sensor shall be an addressable carbon monoxide (CO) sensing module providing both CO toxic gas detection and enhanced fire detection, and shall be listed to UL 268, Smoke Detectors for Fire Alarm Signaling Systems and UL 2075, Gas and Vapor Detectors and Sensors; allowing systems to be listed to UL 2034, Single and Multiple Station Carbon Monoxide Alarms.
2. The CO Sensor shall include CO sensor element mounted in the sensor base which can be easily replaced without replacing the complete sensor base assembly.
3. The CO Sensor base shall provide address selection in the base allowing the address to remain with its location when the sensor is removed for service or type change.
4. The CO Sensor base shall include an integral red LED to indicate the power-on, trouble, test mode or alarm status.

5. CO sensor shall provide enhanced fire detection with the addition of two selectable modes of operation: Nuisance Alarm Reduction Mode and Faster Fire Detection.
6. The CO Sensor shall provide a 10 year life expectancy before replacement is necessary or required.
7. The CO Sensor base shall report the following CO Sensor troubles: Communication loss, Disabled, Almost Expired 12 Months, Almost Expired 6 Months, Expired (End of Life), and Sensor Missing/Failed.
8. Johnson Controls 4098 Series

B. Addressable CO Sensor Sounder Base
1. The CO Sensing element shall support operation with a Sounder base; the CO Sensor Sounder base shall provide temporal code 3 (TC3) for fire, or temporal code 4 (TC4) for toxic carbon monoxide alarms.
2. The CO Sensor Sounder base shall be listed to UL464, Audible Signal Appliances.
3. CO sensor shall provide enhanced fire detection with the addition of two selectable modes of operation: Nuisance Alarm Reduction Mode and Faster Fire Detection.
4. The CO Sensor Sounder Base shall include CO sensor element mounted in the sounder base which can be easily replaced without replacing the complete sensor base assembly.
5. The CO Sensor Sounder base shall provide address selection in the base allowing the address to remain with its location when the sensor is removed for service or type change.
6. The CO Sensor Sounder Sensor base shall include an integral red LED to indicate the power-on, trouble, test mode or alarm status.
7. The CO Sensor Sounder base shall report the following CO Sensor troubles: Communication loss, Disabled, Almost Expired 12 Months, Almost Expired 6 Months, Expired (End of Life), and Sensor Missing/Failed.
8. The CO Sensor Sounder Base shall be interchangeable with the CO Sensor 520 Hz Sounder Base.

C. ADDRESSABLE MULTI-POINT/MULTI-SENSOR/MULTI-CRITERIA SENSOR
1. Smoke and heat sensing shall be available to be combined in a single housing to provide smoke activity accurately monitored by photoelectric sensing technology and thermal activity accurately monitored by thermistor sensing technology.
2. A correlation algorithm of smoke activity and thermal activity shall be provided for intelligent fire detection earlier than with either technology activity alone but shall provide software and programming capabilities to help reduce nuisance alarms.
3. Individual sensor information shall be processed by the host fire alarm control unit to determine sensor status and to determine whether conditions are normal, off-normal, or alarm.
4. Analog information from each sensor type shall be digitally communicated to the control panel where it is to be analyzed. Photoelectric sensor input is to be stored and tracked as an average value with an alarm or abnormal condition being determined by comparing the sensor's present value against its average value. Thermal data is to be processed to look for absolute or rate-of-rise temperature as desired.
5. Monitoring each photoelectric sensor's average value shall provide a software filtering process that compensates for environmental factors (dust, dirt, etc.) and component aging, which shall provide an accurate reference for evaluating new activity. The intent of this process is to be a significant reduction in the probability of false or nuisance alarms caused by shifts in sensitivity, either up or down. Status indications of dirty and excessively dirty shall be automatically generated allowing maintenance to be performed on a per device basis.
6. Peak activity per sensor shall be stored by the host fire alarm control unit to assist in evaluating specific locations where the alarm set point for each sensor shall be capable of

being determined at the control panel, and selectable as more or less sensitive as the individual application requires.

7. Alarm set points shall be programmed for timed automatic sensitivity selection (such as more sensitive at night, less sensitive during day). Control panel programming shall also provide multi-stage operation per sensor, for example a 0.2% level may cause a warning to prompt investigation while a 2.5% level may initiate an alarm.
8. Combination smoke and heat sensors Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute. The fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
9. Bases: CO Sensor, relay output, sounder, 520 Hz Sounder, and isolator bases shall be supported alternatives to the standard base.

2.8 ADDRESSABLE CIRCUIT INTERFACE MODULES

A. Addressable Circuit Interface Modules: Arrange to monitor or control one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of AHU systems.

B. Addressable Circuit Interface Modules will be capable of mounting in a standard electric outlet box. Modules will include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line circuit or a separate two wire pair running from an appropriate power supply, as required.

C. There shall be the following types of modules:
1. Type 1: Monitor Circuit Interface Module:
   a. For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.
   b. For conventional 4-wire smoke detector with Class B wiring supervision. The module will provide detector reset capability and over-current power protection for the 4-wire detector. This module will communicate status (normal, alarm, trouble) to the FACP.
2. Type 2: Line Powered Monitor Circuit Interface Module
   a. This type of module is an individually addressable module that has both its power and its communications supplied by the two wire signaling line circuit. It provides location specific addressability to an initiating device by monitoring normally open dry contacts. This module shall have the capability of communicating four zone status conditions (normal, alarm, current limited, trouble) to the FACP.
   b. This module shall provide location specific addressability for up to five initiating devices by monitoring normally closed or normally open dry contact security devices. The module shall communicate four zone status conditions (open, normal, abnormal, and short). The two-wire signaling line circuit shall supply power and communications to the module.
3. Type 3: Single Address Multi-Point Interface Modules
   a. This multipoint module shall provide location specific addressability for four initiating circuits and control two output relays from a single address. Inputs shall provide supervised monitoring of normally open, dry contacts and be capable of communicating four zone status conditions (normal, open, current limited, and

short). The input circuits and output relay operation shall be controlled independently and disabled separately.

b. This dual point module shall provide a supervised multi-state input and a relay output, using a single address. The input shall provide supervised monitoring of two normally open, dry contacts with a single point and be capable of communicating four zone status conditions (normal, open, current limited, and short). The two-wire signaling line circuit shall supply power and communications to the module.

c. This dual point module shall monitor an unsupervised normally open, dry contact with one point and control an output relay with the other point, using a single address. The two-wire signaling line circuit shall supply power and communications to the module.

4. Type 4: Line Powered Control Circuit Interface Module
   a. This module shall provide control and status tracking of a Form "C" contact. The two-wire signaling line circuit shall supply power and communications to the module.
5. Type 5: 4-20 mA Analog Monitor Circuit Interface Module
   a. This module shall communicate the status of a compatible 4-20 mA sensor to the FACP. The FACP shall annunciate up to three threshold levels, each with custom action message; display and archive actual sensor analog levels; and permit sensor calibration date recording.

D. All Circuit Interface Modules shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an on-board LED to provide an indication that the module is powered and communicating with the FACP. The LEDs shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

E. Johnson Controls 4090 Series

2.9 ADDRESSABLE NOTIFICATION

A. Addressable Notification Appliances: The Contractor shall furnish and install addressable notification appliances and accessories to operate on compatible signaling line circuits (SLC).

1. Addressable Notification appliance operation shall provide power, supervision and separate control of speakers and strobes over a single pair of wires. The controlling channel (SLC) digitally communicates with each appliance and receives a response to verify the appliance's presence on the channel. The channel provides a digital command to control appliance operation. SLC channel wiring shall be unshielded twisted pair (UTP), with a capacitance rating of less than 60pf/ft and a minimum 3 twists (turns) per foot.
2. All Notification Appliances shall operate as a completely independent device allowing for specific location alerting of both fire alarm and Mass Notification functions.
3. All Notification Appliances shall operate as a completely independent device allowing for appliances in handicap accessible rooms and other locations to operate on the same SLC and to activate individually based on an alarm condition in a room or as part of a general alarm condition where all appliances activate together.
4. Individual Notification Appliances shall be able to be grouped into zones (or operational groups) by central programming at the main fire alarm control panel.
5. Notification Appliances shall provide for “unobtrusive” testing. Each Notification Appliance shall be tested for audible and visible operation on an individual basis at the device or from the main fire alarm control panel, allowing for minimal invasive impact.

6. Class B (Style 4) notification appliances shall be wired without requiring traditional in/out wiring methods; addressable "T" Tapping shall be permitted. Up to 63 addresses can be supported on a single channel.
7. Each Addressable notification appliance shall contain an electronic module and a selectable address setting to allow it to occupy a unique location on the channel. This on-board module shall also allow the channel to perform appliance diagnostics that assist with installation and subsequent test operations. A visible LED on each appliance shall provide verification of communications and shall flash with the appliances address setting when locally requested using a magnetic test tool.
8. Each addressable notification appliance shall have electrical test point access without removing the device cover.
9. If a proposed system is not capable of addressable notification, an addressable signal module shall be provided at each appliance, whether it be a speaker, strobe or speaker/strobe appliance.
    a. Each notification appliance shall have its own unique address, and be capable of being programmed to work independently from all other appliances.
    b. Troubleshooting an open NAC circuit will be expedited, by knowing which appliances are communicating with the control panel, and which aren't.

B. Visible/Only: Addressable strobe shall be listed to UL 1971. The V/O device shall consist of a xenon flash tube and associated lens/reflector system, cover and mounting plate. For ease of installation the mounting plate shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. When the appliance is connected to an active circuit, the front cover of the appliance shall be removable without causing a trouble indication on the fire alarm control panel. Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot. The V/O appliance shall be provided with multiple minimum flash intensities of 15cd, 75cd, 110cd, 135cd and 185cd. The Candela levels shall be settable from the fire alarm control panel or by using a hardware selector on the appliance.

C. Audible/Visible: Addressable combination Audible/Visible (A/V) Notification Appliances shall be listed to UL 1971 and UL 464. The strobe device shall consist of a xenon flash tube and associated lens/reflector system, cover and mounting plate. For ease of installation audible/visible mounting plate shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. The strobe shall provide multiple minimum flash intensities of 15cd, 75cd, 110cd, 135cd and 185cd. The Candela levels shall be settable from the fire alarm control panel or using a hardware selector on the appliance. The notification appliance shall produce a peak sound output of 90dba or greater as measured in an anechoic chamber.

D. Isolator Module: Isolator module provides short circuit isolation for addressable notification appliance SLC wiring. Isolator shall be listed to UL 864. The Isolator shall mount directly to a minimum 2 1/8" deep, standard 4" square electrical box, without the use of special adapter or trim rings. Power and communications shall be supplied by the Addressable Controller channel SLC; dual port design shall accept communications and power from either port and shall automatically isolate one port from the other when a short circuit occurs. The following functionality shall be included in the Isolator module:
    1. Report faults to the host FACP.
    2. On-board Yellow LED provides module status.
    3. After the wiring fault is repaired, the Isolator modules shall test the lines and automatically restore the connection.

E. Johnson Controls 49x Series

2.10 ADRESSABLE APPLIANCE SLC REPEATER

A. Addressable Repeater shall supervise channel (SLC) wiring and communicate with and control addressable notification appliances. The Repeater shall be a stand-alone panel capable of powering one (1) NAC SLC. The channel (SLC) shall be rated for 3 amps and support up to 63 addresses. Power and communication for the notification appliances shall be provided on the same pair of wires. It shall be possible to program the High/Low setting of the audible (horn) appliances by channel from the addressable controller.
   1. The Repeater shall provide a constant voltage output to ensure NAC current and voltage do not vary whether the panel is operating on AC or battery. The output voltage during alarm conditions shall be 29 VRMS.
   2. Addressable SLC notification appliance circuits shall be Class B, Style 4
   3. For Class B circuits, the Repeater shall support up to 4 Class B branches directly at its output terminals for one SLC.
   4. The internal power supply and battery charger shall be capable of charging up two 12.7 Ah batteries internally mounted or 25Ah batteries mounted in an external cabinet.
   5. The Repeater panel can be mounted close to the host fire alarm control panel or remotely.
   6. The Repeater status shall be communicated to the host fire alarm control panel and locally indicated.
   7. A 200mA auxiliary output shall be available
   8. The Repeater shall be listed to UL 864

B. Johnson Controls 409x Series

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units shall be listed to UL 228. Units are equipped for wall or floor mounting as indicated and are complete with matching door plate. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source, and develop a minimum of 25 lbs. holding force.

B. Material and Finish: Match door hardware.

2.12 REMOTE LCD ANNUNCIATOR

A. Provide a remote LCD Annunciator, where required, with the same "look and feel" as the FACP operator interface. The Remote LCD Annunciator shall use the same Primary Acknowledge, Silence, and Reset Keys; Status LEDs and LCD Display as the FACP.

B. Annunciator shall have super-twist LCD display with two lines of 40 characters each. Annunciator shall be provided with four (4) programmable control switches and associated LEDs.

C. Under normal conditions the LCD shall display a "SYSTEM IS NORMAL" message and the current time and date.

D. Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory or Trouble) shall flash. The unit audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.

E. The LCD shall display the following information relative to the abnormal condition of a point in the system:
   1. 40 character custom location label.
   2. Type of device (e.g., smoke, pull station, waterflow).
   3. Point status (e.g., alarm, trouble).

F. Operator keys shall be key switch enabled to prevent unauthorized use. The key shall only be removable in the disabled position. Acknowledge, Silence and shall be the same as the FACP.

G. Johnson Controls 46x Series

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

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 or loss of power.
   4. Low battery.
   5. Abnormal test signal.
   6. 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.

2.14 EMERGENCY POWER SUPPLY

A. General: Components include battery, charger, and an automatic transfer switch.

B. Battery: Sealed lead-acid or nickel cadmium type. Provide sufficient capacity to operate the complete alarm system in normal or supervisory (non-alarm) mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm notification devices in alarm mode for a period of 15 minutes.

2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
   1. Factory fabricated and furnished by manufacturer of device.
   2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install system components and all associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.

B. Installation personnel shall be supervised by persons who are qualified and experienced in the installation, inspection, and testing of fire alarm systems. Examples of qualified personnel shall include, but not be limited to, the following:
   1. Factory trained and certified personnel.
   2. National Institute of Certification in Engineering Technologies (NICET) fire alarm level II certified personnel.
   3. Personnel licensed or certified by state or local authority.

3.2 EQUIPMENT INSTALLATION

A. Furnish, modify, and install an upgraded Fire Alarm System as described herein and as shown on the plans. Include sufficient control unit(s), annunciator(s), manual stations, automatic fire detectors, smoke detectors, audible and visible notification appliances, wiring, terminations, electrical boxes, ethernet drops, and all other necessary material for a complete operating system.

B. Existing Fire Alarm Equipment shall be maintained fully operational until the new equipment has been tested and accepted.

C. Install manual station with operating handle 48 inches (1.22 m) above floor. Install wall mounted audible and visual notification appliances not less than 80 inches (2.03 m) above floor to bottom of lens and not greater than 96 inches (2.44 m) above floor to bottom of lens.

D. Mount outlet box for electric door holder to withstand 80 pounds pulling force.

E. Make conduit and wiring connections to door release devices, sprinkler flow switches, sprinkler valve tamper switches, fire suppression system control panels, duct smoke detectors.

F. Automatic Detector Installation: Conform to NFPA 72.

G. Ethernet Drop: A standard RJ-45 Ethernet connection to the owner’s Ethernet network shall be provided at each fire alarm control panel as part of the contract.

3.3 PREPARATION

A. Coordinate work of this Section with other affected work.

3.4 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 Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
   1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) 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 air-conditioning duct systems.
   2. Alarm-initiating connection to elevator recall system and components.

3. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
4. Supervisory connections at valve supervisory switches.
5. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
6. Supervisory connections at elevator shunt trip breaker.

3.5 WIRING INSTALLATION

A. System Wiring: Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the Authority Having Jurisdiction and shall be installed in accordance with the appropriate articles from the current approved edition of NFPA 70: National Electric Code (NEC).

B. Contractor shall obtain from the Fire Alarm System Manufacturer written instruction regarding the appropriate wire/cable to be used for this installation. No deviation from the written instruction shall be made by the Contractor without the prior written approval of the Fire Alarm System Manufacturer.

C. Color Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm initiating device circuits wiring and a different color code for supervisory circuits. Color-code notification appliance circuits differently from alarm-initiating circuits. Paint fire alarm system junction boxes and covers red.

D. Mount end-of-line device in box with last device or separate box adjacent to last device for Class "B" supervision.

E. Ethernet circuits shall be provided to the Fire Alarm Control Panel and Transponder panels as shown on the plans. Where a Fire Alarm Ethernet LAN is specified only Agency Listed Ethernet hardware shall be installed.

F. Exposed cabling in unfinished spaces shall be installed in EMT conduit and painted to match existing wall/ceiling finish. Horizontal runs through walls and vertical runs through floors shall be sleeved in EMT conduit with end bushings and fire caulked.

G. A/V devices for carbon monoxide detection must meet all NYS CO Regulation and Requirements.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

B. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
1. Factory trained and certified.
2. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
3. International Municipal Signal Association (IMSA) fire alarm certified.
4. Certified by a state or local authority.
5. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.

C. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.

D. Inspection:
   1. Inspect equipment installation, interconnection with system devices, mounting locations, and mounting methods.
   2. Verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.

E. Acceptance Operational Tests:
   1. Perform operational system tests to verify conformance with specifications:
      a. Each alarm initiating device installed shall be operationally tested. Each device shall be tested for alarm and trouble conditions. Contractor shall submit a written certification that the Fire Alarm System installation is complete including all punch-list items. Test battery operated emergency power supply. Test emergency power supply to minimum durations specified. Test Supervising Station Signal Transmitter. Coordinate testing with Supervising Station monitoring firm/entity.
      b. Test each Notification Appliance installed for proper operation. Submit written report indicating sound pressure levels at specified distances.
      c. Test Fire Alarm Control Panel and Remote Annunciator.
   2. Provide minimum 10 days notice of acceptance test performance schedule to Owner, and local Authority Having Jurisdiction.

F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.

G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Use NFPA 72 Forms for documentation.

H. Final Test, Record of Completion, and Certificate of Occupancy:
   1. Test the system as required by the Authority Having Jurisdiction in order to obtain a certificate of occupancy. Provide completed NFPA 72 Record of Completion form to Owner and AHJ.

3.7 DEMOSTRATION

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

3.8 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Clean unit internally using methods and materials recommended by manufacturer.

B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound pressure levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

3.9 TRAINING

A. Provide the services of a factory-authorized service representative to demonstrate the system and train Owner's maintenance personnel as specified below.
   1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 8 hours' training.
   2. Schedule training with the Owner at least seven days in advance.

END OF SECTION 284600

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Stripping and stockpiling rock.
6. Removing above- and below-grade site improvements.
7. Disconnecting, capping or sealing, and removing site utilities.
8. Temporary erosion and sedimentation control.

B. Related Requirements:
1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

C. Related Requirements:
1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

1.3 DEFINITIONS

A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.

D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.

E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.6 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
   1. Use sufficiently detailed photographs or video recordings.
   2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

B. Topsoil stripping and stockpiling program.

C. Rock stockpiling program.

D. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

E. Burning: Documentation of compliance with burning requirements and permitting of authorities having jurisdiction. Identify location(s) and conditions under which burning will be performed.

1.7 QUALITY ASSURANCE

A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

B. Rock Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

1.8 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
   1. Do not proceed with work on adjoining property until directed by Architect.

C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify Dig Safe System for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place.

F. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."

G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
   1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."

C. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.

1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed
   1. Arrange with utility companies to shut off indicated utilities.
   2. Owner will arrange to shut off indicated utilities when requested by Contractor.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Architect not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Architect's written permission.

E. Excavate for and remove underground utilities indicated to be removed.

F. Removal of underground utilities is included in earthwork sections; in applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security, and utilities sections; and in Section 024116 "Structure Demolition" and Section 024119 "Selective Demolition."

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Grind down stumps and remove roots larger than 3 inches in diameter, obstructions, and debris to a depth of 18 inches below exposed subgrade.
   3. Use only hand methods or air spade for grubbing within protection zones.
   4. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth indicated on Drawings in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
   1. Limit height of topsoil stockpiles to 72 inches.
   2. Do not stockpile topsoil within protection zones.
   3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
   4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 STOCKPILING ROCK

A. Remove from construction area naturally formed rocks that measure more than 1 foot across in least dimension. Do not include excavated or crushed rock.
   1. Separate or wash off non-rock materials from rocks, including soil, clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

3.8 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Burning tree, shrub, and other vegetation waste is permitted according to burning requirements and permitting of authorities having jurisdiction. Control such burning to produce the least smoke or air pollutants and minimum annoyance to surrounding properties. Burning of other waste and debris is prohibited.

C. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Excavating and filling for rough grading the Site.
2. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
3. Excavating and backfilling for buildings and structures.
4. Drainage course for concrete slabs-on-grade.
5. Subbase course for concrete walks.
6. Subbase course and base course for asphalt paving.
7. Subsurface drainage backfill for walls and trenches.
8. Excavating and backfilling trenches for utilities and pits for buried utility structures.
9. Excavating well hole to accommodate elevator-cylinder assembly.

B. Related Requirements:
1. Section 013200 "Construction Progress Documentation" and Section 013233 "Photographic Documentation" for recording preexcitation and earth-moving progress.
2. Section 033000 "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
3. Section 311000 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
4. Section 312319 "Dewatering" for lowering and disposing of ground water during construction.
5. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
6. Section 316329 "Drilled Concrete Piers and Shafts" for excavation of shafts and disposal of surplus excavated material.
7. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
8. Section 329300 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices for earth moving specified in Section 012200 "Unit Prices."

B. Quantity allowances for earth moving are included in Section 012100 "Allowances."

C. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.
1. 24 inches outside of concrete forms other than at footings.
2. 12 inches outside of concrete forms at footings.
3. 6 inches outside of minimum required dimensions of concrete cast against grade.

4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
5. 6 inches beneath bottom of concrete slabs-on-grade.
6. 6 inches beneath pipe in trencheswide.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
   2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
   3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. Yd. for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

J. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

L. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct preexcavation conference at Project site
   1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
      a. Personnel and equipment needed to make progress and avoid delays.
      b. Coordination of Work with utility locator service.
      c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
      d. Extent of trenching by hand or with air spade.
      e. Field quality control.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:
   1. Geotextiles.
   2. Controlled low-strength material, including design mixture.
   3. Geofoam.
   4. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:
   1. Geotextile: 12 by 12 inches.
   2. Warning Tape: 12 inches long; of each color.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
   1. Classification according to ASTM D 2487.
   2. Laboratory compaction curve according to ASTM D 698

C. Seismic survey report from seismic survey agency.

D. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

1.8 QUALITY ASSURANCE

A. Blasting: Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:
   1. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
   2. Seismographic monitoring during blasting operations.

B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:
   1. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
   2. Seismographic monitoring during blasting operations.

C. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

1.9 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
   1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify "Dig Safe System" for area where Project is located before beginning earth-moving operations.

D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 015000 "Temporary Facilities and Controls" and Section 311000 "Site Clearing" are in place.

E. Do not commence earth-moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.

F. The following practices are prohibited within protection zones:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

G. Do not direct vehicle or equipment exhaust towards protection zones.

H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487 or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

D. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

E. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

F. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

G. Drainage Course: Narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.

H. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and zero to 5 percent passing a No. 4 sieve.

I. Sand: ASTM C 33/C 33M; fine aggregate.

J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   1. Survivability: Class 2; AASHTO M 288.
   2. Survivability: As follows:
      a. Grab Tensile Strength: 157 lbf; ASTM D 4632.
      b. Sewn Seam Strength: 142 lbf; ASTM D 4632.
      c. Tear Strength: 56 lbf; ASTM D 4533.
      d. Puncture Strength: 56 lbf; ASTM D 4833.
   3. Apparent Opening Size: =No. 60 sieve, maximum; ASTM D 4751.
   4. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   1. Survivability: Class 2; AASHTO M 288.
   2. Survivability: As follows:
      a. Grab Tensile Strength: 247 lbf; ASTM D 4632.
      b. Sewn Seam Strength: 222 lbf; ASTM D 4632.
      c. Tear Strength: 90 lbf; ASTM D 4533.
      d. Puncture Strength: 90 lbf; ASTM D 4833.
   3. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
   4. Permittivity: 0.02 per second, minimum; ASTM D 4491.
   5. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting, low-density, flowable concrete material produced from the following:
   1. Portland Cement: ASTM C 150/C 150M, Type II
   2. Fly Ash: ASTM C 618, Class C or F.
   3. Normal-Weight Aggregate: ASTM C 33/C 33M, 3/4-inch nominal maximum aggregate size.
   4. Foaming Agent: ASTM C 869/C 869M.
   5. Water: ASTM C 94/C 94M.
   6. Air-Entraining Admixture: ASTM C 260/C 260M.

2.4 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:
   1. Red: Electric.
   2. Yellow: Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
   4. Blue: Water systems.
   5. Green: Sewer systems.

B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:
   1. Red: Electric.
   2. Yellow: Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
   4. Blue: Water systems.
   5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

B. Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.
   1. Perform blasting without damaging adjacent structures, property, or site improvements.
   2. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   2. Pile Foundations: Stop excavations 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
   3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:
   1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
   2. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.
   1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
   1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
   2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
   3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
   4. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
   1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

E. Trenches in Tree- and Plant-Protection Zones:
   1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
   2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
   3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.8 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.

B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
   1. Completely proof-roll subgrade in one direction**,** repeating proof-rolling in direction perpendicular to first direction.

2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.
1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:
1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring, bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

D. Trenches under Roadways: Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Initial Backfill:
   1. Soil Backfill: Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
      a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
   2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.

G. Final Backfill:
   1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
   2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

H. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:
   1. Under grass and planted areas, use satisfactory soil material.
   2. Under walks and pavements, use satisfactory soil material.
   3. Under steps and ramps, use engineered fill.
   4. Under building slabs, use engineered fill.
   5. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 OIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
   1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
   2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.
3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations.

3.17 SUBSURFACE DRAINAGE

A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698

B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course under pavements and walks as follows:
1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place base course material over subbase course under hot-mix asphalt pavement.
3. Shape subbase course to required crown elevations and cross-slope grades.
4. Place subbase course 6 inches or less in compacted thickness in a single layer.
5. Place subbase course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
6. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698

3.19 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
   1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
   2. Determine that fill material classification and maximum lift thickness comply with requirements.
   3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
   1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length but no fewer than two tests.
   3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length but no fewer than two tests.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
   1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

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 temporary excavation support and protection systems.

B. Related Requirements:
1. Section 013233 "Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
2. Section 312000 "Earth Moving" for excavating and backfilling and for controlling surface-water runoff and ponding.
3. Section 312319 "Dewatering" for dewatering excavations.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
1. Review geotechnical report.
2. Review existing utilities and subsurface conditions.
3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
4. Review proposed excavations.
5. Review proposed equipment.
6. Review monitoring of excavation support and protection system.
7. Review coordination with waterproofing.
8. Review abandonment or removal of excavation support and protection system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include construction details, material descriptions, performance properties, and dimensions of individual components and profiles, and calculations for excavation support and protection system.

B. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer.
1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of soldier piles, piling, lagging, tiebacks, bracing, and other components of excavation support and protection system according to engineering design.
3. Indicate type and location of waterproofing.
4. Include a written plan for excavation support and protection, including sequence of construction of support and protection coordinated with progress of excavation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For land surveyor and professional engineer.

B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Existing Conditions: Using photographs, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.6 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
   1. Notify Architect, Construction Manager and Owner no fewer than three days in advance of proposed interruption of utility.
   2. Do not proceed with interruption of utility without Architects written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from the data.
   1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection according to the performance requirements.
   2. The geotechnical report is referenced elsewhere in Project Manual.

C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.
   1. Contractor Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.
   2. Prevent surface water from entering excavations by grading, dikes, or other means.
   3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
   4. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

2.2 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

D. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.

E. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

F. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

G. Tiebacks: Steel bars, ASTM A 722/A 722M.

H. Tiebacks: Steel strand, ASTM A 416/A 416M.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
   1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that construction and finishing of other work is not impeded.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.
   1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
   1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
   2. Install internal bracing if required to prevent spreading or distortion of braced frames.
   3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.7 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.
   1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction and abandon remainder.
   2. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
   3. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION 315000

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Hot-mix asphalt patching.
2. Hot-mix asphalt paving.
3. Hot-mix asphalt overlay.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
1. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include technical data and tested physical and performance properties.
2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
3. Job-Mix Designs: For each job mix proposed for the Work.

1.4 INFORMATIONAL SUBMITTALS

A. Material Test Reports: For each paving material, by a qualified testing agency.

1.5 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
1. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
2. Asphalt Surface Course: Minimum surface temperature of 50 deg F at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: Sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag meeting the NYSDOT requirements for Coarse Aggregate 703-02.

C. Fine Aggregate: Sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof meeting the NYSDOT requirements for Fine Aggregate 703-01.
1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: ASTM D 242/D 242M, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: NYSDOT Performance Grade Binder designation PG 64S-22.

B. Asphalt Cement: Meeting the requirements of NYSDOT Table 702-2.

C. Tack Coat: Meeting the requirements of NYSDOT Table 702-5 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

D. Water: Potable.

2.3 AUXILIARY MATERIALS

A. Paving Geotextile: Where specified on Contract Drawings. AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

B. Joint Sealant: ASTM D 6690, Type II, hot-applied, single-component, polymer-modified bituminous sealant on NYSDOT-Approved List.

2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes with NYSDOT mix requirements and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: NYSDOT 402.377903.
3. Binder Course: NYSDOT 402.257903. NYSDOT 402.197903 may be required should pavements be left open to traffic over a Winter season. Coordinate final selection with Owner's Representative.
4. Top Course: NYSDOT 402.097303.

B. Emulsified-Asphalt Slurry: ASTM D 3910, Type 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

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

3.2 PREPARATION

A. Protection: Provide protective materials, procedures, and worker training to prevent asphalt materials from spilling, coating, or building up on curbs, driveway aprons, manholes, and other surfaces adjacent to the Work.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.3 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth as indicated on the Contract Documents.
2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, driveway aprons, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Patch surface depressions deeper than 1 inch after milling, before wearing course is laid.
7. Unless otherwise specified in the Contract Documents, remove and legally dispose of milling from the site.
8. Keep milled pavement surface free of loose material and dust.
9. Do not allow milled materials to accumulate on-site.

3.4 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
1. Undersealing: Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd..
1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.5 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.
1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch.
1. Clean cracks and joints in existing hot-mix asphalt pavement.
2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3.6 SURFACE PREPARATION

A. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd..
1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.7 LACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
1. Place hot-mix asphalt base and binder course in single lifts.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at a minimum temperature of 250 deg F.
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.8 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time.
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.9 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
   1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
   1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent or greater than 100 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549/D 3549M.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979/D 979M.
   1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041/D 2041M, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726/D 2726M.
      a. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726/D 2726M.

F. Replace and compact hot-mix asphalt where core tests were taken, if any.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes Concrete Paving Including the Following:
   1. Curbs and gutters.
   2. Walks.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at one of the installation sites.
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

C. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:
   1. Exposed Aggregate: 10-lb Sample of each mix.

D. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:
   1. Cementitious materials.
   2. Steel reinforcement and reinforcement accessories.
   3. Admixtures.
   4. Curing compounds.
   5. Applied finish materials.
   6. Bonding agent or epoxy adhesive.
   7. Joint fillers.

C. Material Test Reports: For each of the following:
   1. Aggregates: Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

   1. Build full size barrier mockup including concrete paving and curbing to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
   2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.8 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
   1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
   2. Do not use frozen materials or materials containing ice or snow.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
   1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
   3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
   1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from galvanized-steel wire into flat sheets.

B. Deformed-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, flat sheet.

C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.

D. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 deformed bars; assembled with clips.

E. Deformed-Steel Wire: ASTM A 1064/A 1064M.

F. Tie Bars: ASTM A 615/A 615M, Grade 60; deformed.

G. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
   1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
   2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

I. Tie Wire: 16 gauge annealed type.

2.4 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:
   1. Portland Cement: ASTM C 150/C 150M, portland cement Type I or Type II.
   2. Fly Ash: ASTM C 618, Class F.

B. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 4S, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service

in similar paving applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1-inch nominal.
2. Percentage passing No. 200 sieve shall be less than 0.7%.
3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
   a. Percentage passing No. 200 sieve shall be less than 3%.

C. Air-Entraining Admixture: ASTM C 260/C 260M.

D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

E. Water: Potable and complying with ASTM C 94/C 94M.

2.5 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

B. Water: Potable.

2.6 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.

B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch.

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

   a. Euclid Chemical Company (The); an RPM company.
   b. Scofield, a Business Unit of Sika Corporation.
   c. W.R. Meadows, Inc.

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience. Proportion design mixes per the recommendations of ACI 211.1.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. Design mixes to meet or exceed each requirement specified. Adjust mix design to meet the most stringent requirement.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
   1. Fly Ash or Pozzolan: 15 percent.
   2. Combined Fly Ash and Pozzolan: 15 percent.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
   1. Air Content: 4-1/2 percent plus or minus 1-1/2 percent for 1-1/2-inch nominal maximum aggregate size.
   2. Air Content: 4-1/2 percent plus or minus 1-1/2 percent for 1-inch nominal maximum aggregate size.
   3. Air Content: 5 percent plus or minus 1-1/2 percent for 3/4-inch nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to0.06 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing, high-range water-reducing or plasticizing and retarding admixture in concrete as required for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

G. Concrete Mixtures: Normal-weight concrete.
   1. Compressive Strength (28 Days): 4000 psi.
   2. Maximum W/C Ratio at Point of Placement: 0.45.
   3. Slump Limit: 4 inches, plus or minus 1 inch.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
   1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
   2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
   3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
   2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."

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

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT INSTALLATION

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
   1. "Hooking-up" or "Walking-in" of any reinforcement will not be permitted.

F. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
   1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
   1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
   2. Provide tie bars at sides of paving strips where indicated.
   3. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
   1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
   2. Extend joint fillers full width and depth of joint.
   3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
   4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
   5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
   6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
   1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/8-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
   2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/8-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

C. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

D. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

F. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
   1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement and joint devices.

G. Screed paving surface with a straightedge and strike off.

H. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
   1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound as follows:
   1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
   1. Elevation: 3/4 inch.
   2. Thickness: Plus 3/8 inch, minus 1/4 inch.
   3. Surface: Gap below 10-feet-long; unleveled straightedge not to exceed 1/2 inch.
   4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
   5. Lateral Alignment and Spacing of Dowels: 1 inch.
   6. Vertical Alignment of Dowels: 1/4 inch.
   7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
   8. Joint Spacing: 3 inches.
   9. Contraction Joint Depth: Plus 1/4 inch, no minus.
   10. Joint Width: Plus 1/8 inch, no minus.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231/C 231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
    a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

F. Concrete paving will be considered defective if it does not pass tests and inspections.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

H. Prepare test and inspection reports.

3.11 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 323113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 REFERENCES

A. Comply with ASTM A 53 for requirements of Schedule 40 piping.

1.3 SUBMITTALS

A. Shop Drawings: Complete detailed drawings for each height and style of fence and gate required. Include separate schedule for each listing all materials required and technical data such as size, weight, and finish, to ensure conformance to specifications.

B. Product Data: Manufacturer's catalog cuts, specifications, and installation instructions for each item specified.

1.4 QUALITY ASSURANCE

A. Comply with standards of the Chain Link Fence Manufacturer's Institute.

B. Provide steel fence and related gates as a complete compatible system including necessary erection accessories, fittings, and fastenings.

C. Posts and rails shall be continuous without splices.

PART 2 - PRODUCTS

2.1 STEEL FRAMEWORK (FOR FENCES UP TO 6'-0" HIGH)

A. End Posts, Corner Posts and Pull Posts:
1. Pipe: 2.375 inches OD, 3.65 pounds per linear foot (Schedule 40).

B. Line Posts:
1. Pipe: 1.90 inches OD, 2.72 pounds per linear foot (Schedule 40).

2.2 STEEL FABRIC

A. One-piece widths for fence heights up to 12'-0".

B. Chain link, 2 inch mesh, No. 9 gauge.

C. Selvages: Top edge and bottom edge knuckled.

2.3 SWING GATE POSTS

A. Single width of gate up to 6'-0" wide and less than 10'-0" high:
1. Pipe: 2.875 inches OD, 5.79 pounds per linear foot (Schedule 40).

B. Single width of gate 6'-0" to 12'-0" wide or over 10'-0" high:
   1. Pipe: 4 inches OD, 9.11 pounds per linear foot (Schedule 40).

2.4 SWING GATE FRAMES

A. Up to 6'-0" high, and leaf width 8'-0" or less.
   1. Pipe: 1.660 inches OD, 2.27 pounds per linear foot (Schedule 40).

B. Assemble gate frames by welding or with special steel fittings and rivets for rigid connections. Install mid-height horizontal rails on gates over 10 feet high. When width of gate leaf exceeds 10 feet, install mid-distance vertical bracing of the same size and weight as frame members. When either horizontal or vertical bracing is not required, provide truss rods as cross bracing to prevent sag or twist.

2.5 SWING GATE HARDWARE

A. Hinges: Non-lift-off type, offset to permit 180 degree swing, and of suitable size and weight to support gate. Provide 1-1/2 pair of hinges for each leaf over 6 feet high.

B. Latch: Forked type for single gates 10 feet wide or less. Drop bar type with keeper for double gates and single gates over 10 feet wide complete with flush plate set in concrete. Drop bar length shall be 2/3 the height of the gate. Padlock eye shall be an integral part of latch construction.

2.6 MISCELLANEOUS MATERIALS AND ACCESSORIES

A. Rails and Post Braces:
   1. Pipe: 1.660 inches OD, 2.27 pounds per linear foot (Schedule 40).

B. Fittings and Post Tops: Steel, wrought iron, or malleable iron.
   1. Fasteners: Tamper-resistant cadmium plated steel screws.

C. Stretcher Bars: One piece equal to full height of fabric, minimum cross-section 3/16 inch by 3/4 inch.

D. Metal Bands (for securing stretcher bars): Steel, wrought iron, or malleable iron.

E. Wire Ties: Conform to American Steel Wire gauges.
   1. For tying fabric to line posts, rails and braces: 9 gauge (.1483 inch) steel wire.

F. Truss Rods: 3/8 inch diameter.

G. Concrete: Portland Cement concrete having a minimum compressive strength of 4000 psi at 28 days.

H. Spiral Paper Tubes:
   1. Sonotube by Sonoco Products Co., North Second St., Hartsville, SC 29550, (800) 377-2692.
   2. Sleek/tubes by Jefferson Smurfit Corp., P.O. Box 66820, St. Louis, Mo 63166, (314) 746-1100.

I. Cold Galvanizing Compound: Single component compound giving 93 percent pure zinc in the dried film, and meeting the requirements of DOD-P-21035A (NAVY).

J. Bolts and Nuts: ASTM A 307, Grade A.

2.7 FINISHES

A. Steel Framework:
   1. Pipe: Galvanized in accordance with ASTM A 53, 1.8 ounces zinc per square foot.

B. Fabric; one of the following:
   1. Galvanized Finish: ASTM A 392 class II zinc coated after weaving, with 2.0 ounces per square foot.
   2. Aluminized Finish: ASTM A 491 aluminum coated with 0.40 ounces per square foot.

C. Fence and Gate Hardware, Miscellaneous Materials, Accessories:
   1. Wire Ties: Galvanized Finish, ASTM A 90 1.6 ounces zinc per square foot, or aluminized finish, ASTM A 809 0.40 ounces per square foot.
   2. Hardware and Miscellaneous Items: Galvanized Finish, ASTM A 153 (Table 1).

D. Tension Wire; one of the following:
   1. Galvanized Finish: ASTM A 121 class 3, 0.80 ounces per square foot.
   2. Aluminized Finish: ASTM A 585 class 2, 0.30 ounces per square foot.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clear and grub along fence line as required to eliminate growth interfering with alignment. Remove debris.

B. Do not begin installation of fence in areas to be cut until finished grading has been completed.

3.2 INSTALLATION

A. Space posts equidistant in the fence line with a maximum of 10 feet on center.

B. Setting Posts in Earth: Drill holes for post footings. If existing grade at the time of installation is below finished grade, provide spiral paper tubes to contain concrete to finish grade elevation. Set posts in center of hole and fill hole with concrete. Plumb and align posts. Vibrate or tamp concrete for consolidation. Finish concrete in a dome shape above finish grade elevation to shed water. Do not attach fabric to posts until concrete has cured a minimum of 7 days.

C. Locate corner posts at corners and at changes in direction. Use pull posts at all abrupt changes in grade and at intervals no greater than 500 feet. On runs over 500 feet, space pull posts evenly between corner or end posts. On long curves, space pull posts so that the strain of the fence will not bend the line posts.

D. Install top rail continuously through post tops or extension arms, bending to radius for curved runs. Install expansion couplings as recommended by fencing manufacturers.

E. Install bottom rails in one piece between posts and flush with post on fabric side using special offset fittings where necessary.

F. Attach fabric to security side of fence. Maintain a 2 inch clearance above finished grade except when indicated otherwise. Thread stretcher bars through fabric using one bar for each gate and end post and 2 for each corner and pull post. Pull fabric tight so that the maximum deflection of fabric is 2 inches when a 30 pound pull is exerted perpendicular to the center of a panel. Maintain tension by securing stretcher bars to posts with metal bands spaced 15 inches oc. Fasten fabric to steel framework with wire ties spaced 12 inches oc for line posts and 24 inches oc for rails and braces. Bend back wire ends to prevent injury. Tighten stretcher bar bands, wire ties, and other fasteners securely.

G. Position bolts for securing metal bands and hardware so nuts are located opposite the fabric side of fence. Tighten nuts and cut off excess threads so no more than 1/8 inch is exposed. Peen ends to prevent loosening or removal of nuts.

H. Install gates plumb and level and adjust for full opening without interference. Install ground-set items in concrete for anchorage, as recommended by fence manufacturer. Adjust hardware for smooth operation and lubricate where necessary.

I. Wire brush and repair welded and abraded areas of galvanized surfaces with one coat of cold galvanizing compound.

J. Restore disturbed ground areas to original condition. Topsoil and seed to match adjacent areas.

END OF SECTION

SECTION 329113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes planting soils specified by composition of the mixes.

B. Related Requirements:
1. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
3. Section 329300 "Plants" for placing planting soil for plantings.

1.3 ALLOWANCES

A. Preconstruction and field quality-control testing are part of testing and inspecting allowance.

1.4 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project Site.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include recommendations for application and use.
   2. Include test data substantiating that products comply with requirements.
   3. Include sieve analyses for aggregate materials.
   4. Material Certificates: For each type of imported soil before delivery to the site, according to the following:
      a. Manufacturer's qualified testing agency's certified analysis of standard products.
      b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
      c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Samples: For each bulk-supplied material, 1-quart volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1.9 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil and imported soil.

1. Notify Architect seven days in advance of the dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
   1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.10 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:
   1. Soil Texture: Soil-particle, size-distribution analysis by[**one of**] the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
      a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
      b. Hydrometer Method: Report percentages of sand, silt, and clay.
   2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D 698 (Standard Proctor).

C. Chemical Testing:
   1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
   2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
   3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
   4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.
2. Class: O, with a minimum of 95 percent passing through a No. 8 sieve and a minimum of 55 percent passing through a No. 60 sieve.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C 33

G. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

H. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

I. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. Ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

J. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

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

3.2 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Spread unamended soil to total depth indicated on Drawings, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
   1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
      a.]Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.3 PROTECTION

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Vehicle traffic.
   4. Foot traffic.
   5. Erection of sheds or structures.
   6. Impoundment of water.
   7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

3.4 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
   1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329113

SECTION 329200 - TURF AND GRASSES

1.1 SUMMARY

A. Section Includes:
1. Seeding.
2. Hydroseeding.
3. Sodding.

1.2 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

F. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.3 ACTION SUBMITTALS

1.4 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

B. Product Certificates: For soil amendments and fertilizers, from manufacturer.

C. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

1.6 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
   1. Spring Planting: May1 through June 15.
   2. Fall Planting: September 1 through October 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.7 MAINTENANCE SERVICE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
   1. Seeded Turf: 60 days from date of planting completion.
      a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

PART 2 - PRODUCTS

2.1 GRASSES

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species: State-certified seed of grass species as follows:
   1. Sun and Partial Shade: Proportioned by weight as follows:
      a. 40 percent Kentucky bluegrass (Poa pratensis).
      b. 30 percent chewings red fescue (Festuca rubra variety).
      c. 30 percent perennial ryegrass (Lolium perenne).
   2. Sod – Full Sun: Kentucky bluegrass (Poa pratensis), a minimum of three cultivars.

2.2 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
   2. Provide lime in form of ground dolomitic limestone or calcitic limestone.

B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Aluminum Sulfate: Commercial grade, unadulterated.

E. Perlite: Horticultural perlite, soil amendment grade.

F. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.

G. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.

D. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.4 FERTILIZERS

A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 percent nitrogen and 10 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.5 PLANTING SOILS

A. Athletic Field Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 0.25 inch or larger in any dimension and other extraneous materials harmful to plant growth.

B. Bioretention Planting Soil: 85 to 90% sand, of which 50% must be within the #10 and #40.sieve, 10-15% fines (<#200 sieve) with 3-5% organic content.

2.6 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 50 to 60 percent of dry weight.
   2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.7 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
   3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
1. Apply fertilizer directly to subgrade before loosening.
2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6 inches of soil. Till soil to a homogeneous mixture of fine texture.
    a. Apply fertilizer directly to surface soil before loosening.
3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   1. Do not use wet seed or seed that is moldy or otherwise damaged.
   2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 3 to 4 lb/1000 sq. ft.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.6 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
   1. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

3.7 SODDING

A. Time limit and option in first paragraph below are requirements of TPI's "Guideline Specifications to Turfgrass Sodding."

B. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

C. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
   1. Lay sod across slopes exceeding 1:3.
   2. Anchor sod on slopes exceeding 1:6 with wood pegs[or steel staples] spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

D. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.8 TURF RENOVATION

A. Renovate existing turf.

B. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
   1. Reestablish turf where settlement or washouts occur or where minor regrading is required.

2. Install new planting soil as required.

C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

E. Mow, dethatch, core aerate, and rake existing turf.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.

I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.

J. Apply seed and protect with straw mulch as required for new turf.

K. Water newly planted areas and keep moist until new turf is established.

3.9 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
   1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
   2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
   3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
   1. Mow to a height of 1-1/2 to 2 inches.

3.10 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Owner’s Representative:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.11 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 329200

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Plants.
2. Tree stabilization.
3. Tree-watering devices.

1.2 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than sizes indicated; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.3 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
   1. Manufacturer's certified analysis of standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

B. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
   1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
   2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

C. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
   1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

H. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

I. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
   1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
   2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   3. Do not remove container-grown stock from containers before time of planting.
   4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.9 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
   1. Warranty Periods: From date of planting completion.
      a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
   2. Include the following remedial actions as a minimum:
      a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
      b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
      c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
      d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
   1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
   2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
   1. Size: 5-gram tablets.
   2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
   1. Type: Shredded hardwood bark.
   2. Size Range: 3 inches maximum, 1/2 inch minimum.
   3. Color: Natural. Confirm with Owner.
   4. Depth: 4".

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

2.5 **Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric,** 4.8 oz./sq. yd.

2.6 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.7 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:
   1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
   2. Wood Deadmen: Timbers measuring 8 inches in diameter and 48 inches long, treated with specified wood pressure-preservative treatment.

B. Root-Ball Stabilization Materials:
   1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated; stakes pointed at one end.
   2. Wood Screws: ASME B18.6.1.

2.8 TREE-WATERING DEVICES

A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
   3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

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

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.3 PLANTING AREA ESTABLISHMENT

A. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade.

B. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.
   1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.

2. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.
3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
7. Maintain supervision of excavations during working hours.
8. or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Owner if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
1. Backfill: Planting soil C300.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
   a. Quantity: Two per plant.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
1. Backfill: Planting soil C300.
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
   a. Quantity: Two per plant.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 MECHANIZED TREE-SPADE PLANTING

A. Trees may be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.

B. Use the same tree spade to excavate the planting hole as will be used to extract and transport the tree.

C. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.

D. Cut exposed roots cleanly during transplanting operations.

E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.

F. Where possible, orient the tree in the same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:
   1. Upright Staking and Tying: Stake trees of 2- through 5-inch caliper. Stake trees of less than 2-inch caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend at least 72 inches above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.

B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than 14 feet in height and more than 3 inches in caliper unless otherwise indicated.

C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

3.9 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines 18 inches apart in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.10 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 12 inches and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

3.11 EDGING INSTALLATION

A. Shovel-Cut Edging: Separate mulched areas from turf areas with a 45-degree, 4- to 6-inch-deep, shovel-cut edge.

3.12 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

3.13 PLANT MAINTENANCE

A. Maintain plantings by watering as required to establish healthy, viable plantings.

3.14 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.15 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
   1. Provide new trees of same size as those being replaced for each tree.

3.16 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.17 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
   1. Maintenance Period: 12 months from date of planting completion.

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
   1. Maintenance Period: 12 months from date of planting completion.

END OF SECTION 329300

ECTION 329300

SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 CONTRACT CONDITIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary conditions and Division 1 Specifications apply to this Section.

1.2 SUMMARY

A. Work under this Section includes all labor, materials, services and equipment necessary for construction of a storm sewer system.

1.3 RELATED SECTIONS

A. Excavating, Grading, and Shoring 02000

B. Erosion Control 02270

1.4 REFERENCES

A. ASTM A48-92, “Gray Iron Castings”

B. ASTM A307-92, “Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength”

C. ASTM C76-90, “Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe”

D. ASTM C144-91, “Aggregate for Masonry Mortar”

E. ASTM C150-92, “Portland Cement”

F. ASTM C443-85 (1990), “Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets”

G. ASTM C478-90, “Precast Reinforced Concrete Manhole Sections”

H. ASTM Cl 107-91a, “Packaged, Dry, Hydraulic - Cement Grout (Non-Shrink)”

I. ASTM D2321-89, “Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Floor Applications”

J. ASTM D2564-091, “Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings”

K. ASTM D2855-90, “Practice for Making Solvent-Cemented Joint Poly Vinyl Chloride (PVC) Pipe and Fittings”

L. ASTM D3034-89, “Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings”

M. ASTM D3212, “Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals”

1.5 SUBMITTALS

A. Comply with Section 01300 - Submittals.

B. Submit shop drawings and/or product data for:
   1. Manholes
   2. Catch basins
   3. Castings

C. Mill certification of materials for pipe and joint materials.

D. Contractor shall submit alignment and grade report.

1.6 QUALITY ASSURANCE

A. Employ an experienced construction surveyor to establish horizontal and vertical control.

1.7 PROJECT RECORD DOCUMENTS

A. Submit documents in accordance with Division One.

B. Accurately record location of new storm sewers, horizontal dimensions, elevations of inverts and rims, and slope gradients.

1.8 REGULATORY REQUIREMENTS

A. Coordinate utility work to protect existing and concurrent construction. Obtain approval prior to interruption of existing utilities.

1.9 DELIVERY, STORAGE AND HANDLING

A. Storage
   1. Store pipe and appurtenances to prevent damage by weight deflection, heat, sunlight, or other environmental conditions. If a specific pipe material is subject to deformation from specific environmental conditions, deliver and store pipe in enclosed or shaded transport with controlled environment as necessary to protect pipe until pipe has been installed.

B. Handling
   1. Take extreme care in the handling of pipe to prevent damage prior to installation; protect ends of piping materials including fittings from damage prior to jointing.

1.10 SITE CONDITIONS

A. Lengths indicated on the Drawings are for information only. Furnish lengths as required.

B. Existing utilities are shown on the drawings by general location only. The Contractor shall be responsible for verifying the exact location of each utility.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Pipe and fittings by manufacturer who has made pipe successfully and continuously for the immediate past five (5) years or longer.

2.2 MATERIALS

A. Storm Sewer Pipe
   1. Reinforced Concrete Pipe (RCP): Pipe, ASTM C76, Class 3 or as indicated otherwise on drawings.
   2. Poly Vinyl Chloride (PVC): Pipe and Fittings, ASTM D3034, Class SDR 35.
   3. Smooth Interior Corrugated Polyethylene Pipe (SICPP)
      a. Smooth Interior Corrugated Polyethylene Pipe supplied under this specification shall be high density polyethylene pipe with a corrugated exterior and smooth

interior. 4" through 10" diameters shall meet AASHTO M252 Specifications. 12" through 48" diameters shall meet AASHTO M294 Specifications. 54" through 60" diameters shall meet AASHTO MP7-97 Specifications.

b. Material shall meet ASTM D3350 resin cell classification 335420C.
c. Flow calculations shall be based on Mannings "n" value of 0.012.
d. Joints shall consist of a bell and spigot type joint with an o-ring rubber gasket meeting ASTM F477 placed on the spigot end. At least two (2) corrugations of the spigot end must insert into the bell end.
e. Pipe fittings shall conform to AASHTO M294 or as designated by the Engineer.
f. Pipe shall be N-12 Prolink Ultra as manufactured by Advanced Drainage Systems, Inc. Hancor Sure Lok F477 or equal.

B. Joints and Joint Materials
1. Reinforced concrete pipe joints shall meet the requirements of ASTM C443, rubber gasket joints.
2. Polyvinyl chloride pipe joints shall be bell and spigot type with solvent cement meeting the requirements of ASTM D2564 and applied according to the manufacturer's recommendation and ASTM D2855. Gasketed push-on type joints are considered equal, ASTM D3212.

C. Pre-Cast concrete Structures
1. Pre-cast Concrete Manhole Sections, ASTM C478.
2. 0-Ring rubber gaskets, ASTM C443.
3. A 12" or 16" manhole collar shall be installed below the cone section on all manholes.
4. Pipes shall be connected to manholes by pre-cast in rubber boots or grouted in place.
5. The manhole shall be water tight.

D. Manhole Steps: Manhole steps shall be cast-iron conforming to the requirements of ASTM C478 or aluminum alloy similar in design to the cast-iron specified.

E. Mortar Mix: One part Type 1, ASTM C 150, cement by volume and three parts clean and sharp sand by volume, ASTM C144.

F. Invert Shaping Grout: One part Type 1, ASTM C 150, cement by volume, two parts clean and sharp, ASTM C33, sand by volume, and 1½ parts 1/4" ASTM C33, aggregate by volume.

G. Non-Shrink Grout: ASTM C1107.

H. Tie Bolts, Nuts, Washers: ANSI coarse THD Series, CL2A bolts, CUB nuts, strength ASTM A307 for bends and flared end section.

2.3 SOURCE QUALITY CONTROL

A. Inspect for compliance with the following upon delivery:
1. Allowable deviation from straightness for non-flexible piping materials: 1/8" per foot of length up to 3/4" in six feet as measured from concave side of pipe. Deviations greater than 3/4" not acceptable regardless of length. Pipe with diameter variations not compensated for in joint or resulting from deformations to pipe after leaving mill may be rejected.
2. In addition to rejection for non-conformance to product specifications, precast and cast-in-place items may be rejected for any of the following reasons:
a. Fractures or cracks passing through the wall, except for a single end crack in circular sections that does not exceed the depth of the joint.
b. Defects that indicate imperfect proportioning, mixing, and molding.
c. Surface defects indicating honeycombed or open texture.

d. Damaged ends in circular sections where such damage would prevent making a satisfactory joint.

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide temporary protection for the following during installation of site drainage for:
   1. Existing utilities bench marks, existing structures, property corner monuments and private property.
   2. The traveling public

B. Verify locations, elevations, and depths of existing utilities prior to open cut trenching or tunneling.

C. If pipe elevations conflict, notify Engineer in writing. Do not proceed until Engineer approves resolution of conflict.

D. Do not install pipe in fill until fill is placed to an elevation two (2) feet above top of pipe and compacted to specified density.

3.2 TRENCH EXCAVATION

A. Determine alignment and grade of each pipe line and mark by means of offset stakes.

B. Do not open more trench in advance of pipe laying than is necessary to expedite the work. Refer to Section 02000 - Excavating, Backfilling and Shoring.

C. Protect excavations from cave-ins, restrict access to authorized personnel.

3.3 INSTALLATION OF PIPE SEWERS

A. Refer to Section 02000 - Excavating, Backfilling and Shoring

B. Lay pipe upgrade beginning at the outlet end with the spigot or tongue ends pointing in the direction of flow.

C. Place pipe to the grades and alignment shown on the Drawings. Fit and match joints to form a smooth, continuous, undisturbed surface, true in line and grade.

D. During installation, protect open ends of the pipe against damage and keep the pipe ends free of excavated materials and backfill.

E. Do not lay pipe when trench conditions or weather is unsuitable for such work.

F. Bed pipe uniformly throughout its entire length, as indicated and as follows:
   1. Unless shown otherwise, Class C-1 bedding system.
   2. When a Uniform trench bottom cannot be formed, Class C-2 bedding shall be used.
   3. Lay PVC pipe (PVC or PE) in accordance with ASTM D2321 with granular materials as specified in 02000. The granular materials shall be placed from a point 6” below the bottom of the pipe to a point 12” above the top of the pipe. Bedding shall include mechanical compaction to 95% maximum standard proctor density.

G. Lay no pipe in water unless indicated or approved.

H. Construct deflections from a straight line or grade as required by vertical or horizontal curves or offsets, but not exceeding 6/D” per foot of pipe, where D represents nominal pipe diameter expressed in inches with deflection measured between extended center lines of any two connecting

lengths of pipe. For alignments requiring deflections in excess of the foregoing, use shorter lengths and fittings.

3.4 PIPE JOINTING

A. General
1. Make joints in the sewer pipe regardless of the type of pipe used, in accordance with the manufacturer's published recommendations. Seal joints not having factory fabricated seals to provide a watertight joint, using joint sealer material. Fill annular space with joint filler, between male and female ends of pipe, with ends firmly butted.
2. Thoroughly clean and dry, where applicable, inside and outside of pipe at joints prior to jointing. Remove dirt, foreign materials, excess coating materials and other materials that may damage or reduce effectiveness of joint.
3. Plug lift holes in reinforced concrete pipe with a precast concrete plug, sealed and covered with sealer or mortar.

B. Concrete Pipe Joints
1. Apply the manufacturer's recommended lubricant compound over the entire joint surface and then insert spigot end into the bell with enough force to properly seat the pipe.
2. Provide 0-ring gasket joints.
3. At bends and flared end sections and where indicated on Drawings, tie together concrete pipe with tie bolts.
4. Where a sewer line outlets to grade with a flared end section, fasten the last three joints together by the use of U bolt fasteners as recommended by the pipe manufacturer.

C. Polyvinyl Chloride Pipe Joints: Joints shall be made by use of a solvent cement or push-on rubber gaskets.

3.5 STRUCTURE INSTALLATION

A. Construct structures including but not limited to manholes and control structures as indicated on the drawings.

B. Place structures on undisturbed earth if possible. Otherwise compact foundation grade as indicated in Section 02000 - Excavating, Backfilling and Shoring.

C. If pre-cast segmental blocks are used for structures, apply cement mortar coating on exterior with minimum thickness of 1/2".

D. Provide a minimum of two and a maximum of four adjusting rings under casting.

E. Set cover frame or ring casting to indicated elevation using precast adjusting rings set in full mortar bed and the exterior of the adjusting rings shall be given a mortar coating.

F. Install performed joint seal in accordance with manufacturer's recommendations.

G. Seal interior joints which indicate infiltration, lift holes and manhole steps with non-shrink grout.

H. Adjust castings to 1/4" to 3/4" below pavement or flush with landscaped areas.

3.6 SURFACING AND RESTORATION

A. Surface areas of storm sewer construction as indicated and specified.

B. Where storm sewer construction is located on private property, undisturbed by other current construction, restore area to original condition. Restore existing private paved areas with paving section equal to or better than contiguous areas.

3.7 FIELD QUALITY CONTROL

A. Allow the Engineer full access to Work to observe the following:
   1. Pipe jointing and bedding.
   2. Surface restoration.

B. Propose procedures to correct non-conforming work in writing to the Engineer.

C. Alignment and Grade
   1. Clean and lamp sewers and drainage systems between each structure. Determine construction elevations of invert(s) and top of casting of each structure.
   2. Submit compliance report prior to acceptance of project.

END OF SECTION

3.8