PROJECT MANUAL
VOLUME 02: DIVISIONS 21 THROUGH 31

Charles County Animal Care Center

Project No: 18-034

Piney Church Road
Waldorf, Maryland 20602

PREPARED FOR:

CHARLES COUNTY
10430 Audie Lane
La Plata, Maryland 20646

Bid Documents
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TABLE OF CONTENTS

VOLUME 02: DIVISIONS 22 THROUGH 31

SECTION 21 0500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 REFERENCE STANDARDS

A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators; 2017.

B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2015.

C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2016.

D. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250; 2016.

E. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard; 2017.

F. ASME B16.9 - Factory-Made Wrought Buttwelding Fittings; 2018.

G. ASME B16.11 - Forged Fittings, Socket-welding and Threaded; 2016 (Errata 2017).

H. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.

I. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2018.

J. ASME B16.25 - Buttwelding Ends; 2012.

K. ASME B36.10M - Welded and Seamless Wrought Steel Pipe; 2018.

L. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2018).

M. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2018.

N. ASTM A135/A135M - Standard Specification for Electric-Resistance-Welded Steel Pipe; 2009 (Reapproved 2014).

O. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2018a.

P. ASTM A536 - Standard Specification for Ductile Iron Castings; 1984 (Reapproved 2014).

Q. ASTM A795/A795M - Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use; 2013.

R. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2013a (Reapproved 2017).

S. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2015, with Errata (2016).

T. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems; 2010.

U. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings; 2012.

V. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; 2017.

W. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast; 2017.

X. AWWA C606 - Grooved and Shouldered Joints; 2015.

Y. FM (AG) - FM Approval Guide; current edition.

Z. ITS (DIR) - Directory of Listed Products; current edition.

AA. NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

AB. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems; 2016.

AC. UL (DIR) - Online Certifications Directory; Current Edition.

1.2 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturers catalogue information. Indicate valve data and ratings.

C. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

D. Project Record Documents: Record actual locations of components and tag numbering.

E. Operation and Maintenance Data: Include installation instructions and spare parts lists.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Comply with FM (AG), UL (DIR), and ITS (DIR) or Warnock Hersey requirements.

C. Valves: Bear FM (AG), UL (DIR), and ITS (DIR) or Warnock Hersey product listing label or marking. Provide manufacturer's name and pressure rating marked on valve body.

D. Products Requiring Electrical Connection: Listed and classified as suitable for the purpose specified and indicated.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers, with labeling in place.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 PRODUCTS

2.1 FIRE PROTECTION SYSTEMS

A. Sprinkler Systems: Comply with NFPA 13.

B. Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.2 BURIED PIPING

A. Steel Pipe: ASTM A53/A53M Schedule 40, ASTM A135/A135M Schedule 10, ASTM A795/A795M Standard Weight, or ASME B36.10M Schedule 40, black, with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.
   1. Steel Fittings: ASME B16.9, wrought steel, buttwelded, ASME B16.25, buttweld ends, ASTM A234/A234M, wrought carbon steel or alloy steel, ASME B16.5, steel flanges and fittings, or ASME B16.11, forged steel socket welded and threaded; with double layer, half-lapped polyethylene tape.
   2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings.
   3. Joints: Welded in accordance with AWS D1.1/D1.1M.
   4. Casing: Closed glass cell insulation.

B. Ductile Iron Pipe: AWWA C151/A21.51.
   1. Fittings: AWWA C110/A21.10, standard thickness.
   2. Joints: AWWA C111/A21.11, styrene butadiene rubber (SBR) or vulcanized SBR gasket.
   3. Mechanical Couplings: Shaped composition sealing gasket, steel bolts, nuts, and washers.

2.3 ABOVE GROUND PIPING

A. Steel Pipe: ASTM A53 Schedule 40 or ASTM A135/A135M Schedule 10, black.
   1. Steel Fittings: ASME B16.9, wrought steel, buttwelded, ASME B16.25, buttweld ends, ASTM A234/A234M, wrought carbon steel or alloy steel, ASME B16.5, steel flanges and fittings, or ASME B16.11, forged steel socket welded and threaded.
   2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings and ASME B16.4, threaded fittings.
   3. Malleable Iron Fittings: ASME B16.3, threaded fittings and ASTM A47/A47M.
   4. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

5. Mechanical Formed Fittings: Carbon steel housing with integral pipe stop and O-ring pocked and O-ring, uniformly compressed into permanent mechanical engagement onto pipe.

2.4 PIPE SLEEVES

A. Plastic, Sheet Metal, or Moisture-Resistant Fiber: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.

B. Pipe Passing Through Below Grade Exterior Walls:
   1. Zinc coated or cast iron pipe.
   2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.

C. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:
   1. Galvanized steel pipe or black iron pipe with asphalt coating.
   2. Connect sleeve with floor plate except in mechanical rooms.

D. Not required for wall hydrants for fire department connections or in drywall construction.

E. Clearances:
   1. Provide allowance for insulated piping.
   2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
   3. Rated Openings: Caulked tight with fire stopping material complying with ASTM E814 in accordance with Section 07 8400 to prevent the spread of fire, smoke, and gases.

2.5 PIPE HANGERS AND SUPPORTS

A. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.

B. Hangers for Pipe Sizes 2 inches and Over: Carbon steel, adjustable, clevis.

C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

D. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.

E. Wall Support for Pipe Sizes 4 inches and Over: Welded steel bracket and wrought steel clamp.

F. Vertical Support: Steel riser clamp.

G. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

2.6 MECHANICAL COUPLINGS

A. Rigid Mechanical Couplings for Grooved Joints:
   1. Dimensions and Testing: Comply with AWWA C606.
   2. Minimum Working Pressure: 300 psig.
   3. Housing Material: Fabricate of ductile iron complying with ASTM A536.

4. Housing Coating: Factory applied orange enamel.
5. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
6. Bolts and Nuts: Hot dipped galvanized or zinc electroplated steel.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and foreign material, from inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install sprinkler system and service main piping, hangers, and supports in accordance with NFPA 13.

B. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.

C. Install piping to conserve building space, to not interfere with use of space and other work.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Pipe Hangers and Supports:
   1. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
   2. Place hangers within 12 inches of each horizontal elbow.
   3. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
   4. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
   5. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

H. Prepare pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

I. Do not penetrate building structural members unless indicated.

J. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.

K. Manufactured Sleeve-Seal Systems:
   1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
   2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
   3. Locate piping in center of sleeve or penetration.
   4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
   5. Tighten bolting for a water-tight seal.
   6. Install in accordance with manufacturer's recommendations.

L. Escutcheons:
   1. Install and firmly attach escutcheons at piping penetrations into finished spaces.
   2. Provide escutcheons on both sides of partitions separating finished areas through which piping passes.
   3. Use chrome plated escutcheons in occupied spaces and to conceal openings in construction.

M. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

END OF SECTION

SECTION 21 0553 - IDENTIFICATION FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Stencils.

D. Pipe markers.

E. Ceiling tacks.

1.2 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2015.

B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

1.3 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Manufacturer's Installation Instructions: Indicate special procedures, and installation instructions.

E. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Automatic Controls: Tags.

B. Control Panels: Nameplates.

C. Instrumentation: Tags.

D. Major Control Components: Nameplates.

E. Piping: Tags.

F. Pumps: Nameplates.

G. Relays: Tags.

H. Small-sized Equipment: Tags.

I. Thermostats: Nameplates.

J. Valves: Nameplates and ceiling tacks where above lay-in ceilings.

2.2 NAMEPLATES

A. Description: Laminated three-layer plastic with engraved letters.
   1. Letter Color: White.
   2. Letter Height: 1/4 inch.
   3. Background Color: Black.
   4. Thickness: 1/8 inch.
   5. Plastic: Comply with ASTM D709.

2.3 TAGS

A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

2.4 STENCILS

A. Stencils: With clean cut symbols and letters of following size:
   1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
   2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
   3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.

B. Paint for Stencils: As specified in Section 09 9123, semi-gloss enamel, colors complying with ASME A13.1.

2.5 PIPE MARKERS

A. Color: Comply with ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

E. Color code as follows:
   1. Fire Quenching Fluids: Red with white letters.

2.6 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Section 09 9123 for stencil painting.

3.2 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Apply stencil painting in accordance with Section 09 9123.

D. Install plastic pipe markers in accordance with manufacturer's instructions.

E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

G. Use tags on piping 3/4 inch diameter and smaller.
   1. Identify service, flow direction, and pressure.
   2. Install in clear view and align with axis of piping.
   3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

H. Locate ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

SECTION 21 1300 - FIRE-SUPPRESSION SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Wet-pipe sprinkler system.

B. System design, installation, and certification.

C. Fire department connections.

1.2 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 21 0500 - Common Work Results for Fire Suppression: Pipe and fittings.

C. Section 21 0548 - Vibration and Seismic Controls for Fire Suppression Piping and Equipment.

D. Section 21 0553 - Identification for Fire Suppression Piping and Equipment.

E. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.

F. Section 22 0553 - Identification for Plumbing Piping and Equipment.

1.3 REFERENCE STANDARDS

A. FM (AG) - FM Approval Guide; current edition.

B. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements; 2015.

C. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements; 2015.

D. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements; 2015.

E. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements; 2016.

F. ITS (DIR) - Directory of Listed Products; current edition.

G. NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

H. NFPA 1963 - Standard for Fire Hose Connections; 2014.

I. UL (DIR) - Online Certifications Directory; Current Edition.

J. UL 405 - Fire Department Connection Devices; Current Edition; Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Convene one week before starting work of this section.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

C. Shop Drawings:
   1. Submit preliminary layout of finished ceiling areas indicating only sprinkler locations coordinated with ceiling installation.
   2. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
   3. Submit shop drawings to Authorities Having Jurisdiction for approval. Submit proof of approval to DEDC, LLC.

D. Manufacturer's Certificate: Certify that system has been tested and meets or exceeds specified requirements and code requirements.

E. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Sprinklers: Type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
   3. Sprinkler Wrenches: For each sprinkler type.

1.6 QUALITY ASSURANCE

A. Comply with FM (AG) requirements.

B. Designer Qualifications: Design system under direct supervision of a Professional Engineeror NICET Level III designer experienced in design of this type of work and licensed in the State of Maryland.

C. Equipment and Components: Provide products that bear FM (AG) label or marking.

D. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Sprinklers, Valves, and Equipment:
   1. Tyco Fire Protection Products: www.tyco-fire.com/#sle.
   2. Viking Corporation: www.vikinggroupinc.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. UL Listed for Fire Protection Services

2.2 SPRINKLER SYSTEM

A. Sprinkler System: Provide coverage for entire building.

B. Interface system with building fire and smoke alarm system.

C. Provide fire department connections where indicated.

D. Storage Cabinet for Spare Sprinklers and Tools: Steel, located adjacent to alarm valve.

2.3 SPRINKLERS

A. Suspended Ceiling Type: Semi-recessed pendant type with matching push on escutcheon plate.
   1. Response Type: Quick.
   2. Finish: Brass.
   3. Escutcheon Plate Finish: Antique Brass.

B. Exposed Area Type: Standard upright type with guard (where sprinkler is lower than seven feet above finished floor
   1. Response Type: Quick.
   2. Coverage Type: Standard.

C. Sidewall Type: Semi-recessed horizontal sidewall type with matching push on escutcheon plate.
   1. Response Type: Quick.
   2. Coverage Type: Standard.
   3. Finish: Brass.
   4. Fusible Link: Fusible solder link type temperature rated for specific area hazard.

D. Storage Sprinklers: Pendant type with guard.
   1. Response Type: Standard.
   2. Coverage Type: Standard.

3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.

E. Guards: Finish to match sprinkler finish.

F. Flexible Drop System: Stainless steel, multiple use, open gate type.
1. Application: Use to properly locate sprinkler heads.
2. Include all supports and bracing.
3. Provide braided type tube as required for the application.

2.4 PIPING SPECIALTIES

A. Backflow Preventer: Reduced pressure principle valve assembly backflow preventer with drain and OS & Y gate valve on each end.

B. Test Connections:
1. Inspector's Test Connection:
a. AGF Test and Drain or equal. Drain outside of building.
2. Backflow Preventer Test Connection:
a. Furnish one valve for each 250 gpm of system demand or fraction thereof.
b. Provide permanent sign reading "Test Valve" in accordance with Section 22 0553.

C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC.

D. Fire Department Connections:
1. Type: Flush, wall mount made of corrosion resistant metal complying with UL 405.
a. Inlets: Two way, 2-1/2 inch swivel fittings, internal threaded. Thread size and inlets according to NFPA 1963 or Authority Having Jurisdiction. Brass caps with gaskets, chains, and lugs.
b. Configuration: Horizontal.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with referenced NFPA design and installation standard.

B. Install equipment in accordance with manufacturer's instructions.

C. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent siamese connectors to allow full swing of fire department wrench handle.

D. Place pipe runs to minimize obstruction to other work.

E. Place piping in concealed spaces above finished ceilings.

F. Center sprinklers in two directions in ceiling tile and provide piping offsets as required.

G. Flush entire piping system of foreign matter.

H. Install guards on sprinklers in exposed ceilings where less than seven feet above finished floor..

I. Hydrostatically test entire system.

J. Require test be witnessed by Fire Marshal.

3.2 INTERFACE WITH OTHER PRODUCTS

A. Ensure required devices are installed and connected as required to fire alarm system.

3.3 SCHEDULES

A. System Hazard Areas: As indicated on Drawings

END OF SECTION

SECTION 22 0500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
6. Grout.
7. Plumbing demolition.
8. Equipment installation requirements common to equipment sections.
9. Concrete bases.
10. Supports and anchorages.

1.2 DEFINITIONS

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

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

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

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

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

1.3 SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

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

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
    a. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

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

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

2.2 JOINING MATERIALS

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

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12.

G. Solvent Cements for Joining Plastic Piping:
    1. ABS Piping: ASTM D 2235.
    2. CPVC Piping: ASTM F 493.
    3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
    4. PVC to ABS Piping Transition: ASTM D 3138.
    5. DIELECTRIC FITTINGS
        a. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
        b. Insulating Material: Suitable for system fluid, pressure, and temperature.
        c. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
        d. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

e. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
f. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.3 MECHANICAL SLEEVE SEALS

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

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.4 SLEEVES

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

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

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.5 ESCUTCHEONS

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

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

C. One-Piece, Cast-Brass Type: With set screw.
1. Finish: Polished chrome-plated and rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated and rough brass.

2.6 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

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

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

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

L. Install escutcheons for penetrations of walls, ceilings, and floors.

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

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using 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.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
   3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

Q. Verify final equipment locations for roughing-in.

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

3.3 PIPING JOINT CONSTRUCTION

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

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

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

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

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

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   5. PVC Nonpressure Piping: Join according to ASTM D 2855.
   6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

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

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. 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. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

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

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

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

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

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

D. ERECTION OF WOOD SUPPORTS AND ANCHORAGES

E. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
1. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
2. Attach to substrates as required to support applied loads.

3.8 GROUTING

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

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

END OF SECTION

SECTION 22 0516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Flexible pipe connectors.

B. Expansion joints and compensators.

C. Pipe loops, offsets, and swing joints.

1.2 REFERENCE STANDARDS

A. ASTM A269/A269M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service; 2015a.

B. EJMA (STDS) - EJMA Standards; Tenth Edition.

1.3 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data:
   1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
   2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.

C. Design Data: Indicate selection calculations.

D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Packing for Packed Expansion Joints: One set for each joint.

PART 2 PRODUCTS

2.1 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

A. Manufacturers:
   1. Mercer Rubber Company; _____: www.mercer-rubber.com/#sle.
   2. The Metraflex Company; _____: www.metraflex.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Inner Hose: Carbon steel.

C. Exterior Sleeve: Single braided, stainless steel.

D. Pressure Rating: 125 psi and 450 degrees F.

E. Joint: Flanged.

F. Size: Use pipe sized units.

G. Maximum offset: 3/4 inch on each side of installed center line.

2.2 FLEXIBLE PIPE CONNECTORS - COPPER PIPING

A. Manufacturers:
   1. Mercer Rubber Company; _____: www.mercer-rubber.com/#sle.
   2. The Metraflex Company; _____: www.metraflex.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Inner Hose: Bronze.

C. Exterior Sleeve: Braided bronze.

D. Pressure Rating: 125 psi and 450 degrees F.

E. Joint: Flanged.

F. Size: Use pipe sized units.

G. Maximum offset: 3/4 inch on each side of installed center line.

H. Application: Copper piping.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install flexible pipe connectors on pipes connected to vibration isolated equipment. Provide line size flexible connectors.

C. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

D. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

END OF SECTION

SECTION 22 0523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Brass ball valves.
2. Bronze ball valves.
3. Iron, single-flange butterfly valves.
4. Iron, grooved-end butterfly valves.
5. Bronze lift check valves.
6. Bronze swing check valves.
7. Iron swing check valves.
8. Iron, grooved-end swing check valves.
9. Bronze globe valves.
10. Chainwheels.

1.3 RELATED SECTIONS:

A. Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

B. Section 221113 "Facility Water Distribution Piping" for valves applicable only to this piping.

C. Section 221116 "Domestic Water Piping" for valves applicable only to this piping.

D. Section 221319 "Sanitary Waste Piping Specialties" for valves applicable only to this piping.

1.4 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.

1.5 ACTION SUBMITTALS

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

1.6 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.
4. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.7 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
3. USE SLING TO HANDLE LARGE VALVES; RIG SLING TO AVOID DAMAGE TO EXPOSED PARTS. DO NOT USE HANDWHEELS OR STEMS AS LIFTING OR RIGGING POINTS

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. Valves shall be American made.

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

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

E. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.

2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller[except plug valves].
4. Wrench: For plug valves with square heads. Furnish Cleveland Clinic with 1 wrench for every [5] [10] 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.

F. Valves in Insulated Piping: With 2-inch (50-mm) 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.

G. 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.

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

2.2 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hammond Valve.
b. Milwaukee Valve Company.
c. Mueller.
d. Watts.
e. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

B. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hammond Valve.
b. Milwaukee Valve Company.

c. Mueller
d. Watts.
e. Conbraco Industries, Inc.; Apollo Valves.

2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

C. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Three piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Mueller.
b. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Three piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.

i. Ball: Stainless steel, vented.
j. Port: Full.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
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. Hammond Valve.
d. Milwaukee Valve Company.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

B. 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. Hammond Valve.
c. Milwaukee Valve Company.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

C. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conbraco Industries, Inc.; Apollo Valves.

b. Hammond Valve.
c. Milwaukee Valve Company.
d. Red-White Valve Corporation.

2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Three piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Three-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. Hammond Valve.
c. Milwaukee Valve Company.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Three 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.

2.4 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. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Center Line.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. DeZurik Water Controls.
e. Hammond Valve.
f. Milwaukee Valve Company.
g. Mueller Steam Specialty; a division of SPX Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:

a. Standard: MSS SP-67, Type I, API 609.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Lug type; suitable for bidirectional double dead-end service at full rated pressure 2" through 12" without use of downstream flange. Field replaceable hard phenolic backed liner.
d. Stem: One- or two-piece 416 stainless steel.
e. Disc: Aluminum bronze.

B. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat:
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; Center Line.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. DeZurik Water Controls.
e. Hammond Valve.
f. Milwaukee Valve Company.
g. Mueller Steam Specialty; a division of SPX Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-67, Type I, API 609.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Lug type; suitable for bidirectional double dead-end service at full rated pressure 2" through 12" without use of downstream flange. Field replaceable hard phenolic backed liner.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: NBR.
f. Stem: One- or two-piece 416 stainless steel.
g. Disc: Nickel-plated[or -coated] ductile iron.

C. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
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; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. DeZurik Water Controls.
e. Hammond Valve.
f. Milwaukee Valve Company.
g. Mueller Steam Specialty; a division of SPX Corporation.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig (1380 kPa).

c. Body Design: Lug type; suitable for bidirectional double dead-end service at full rated pressure 2" through 12" without use of downstream flange. Field replaceable hard phenolic backed liner.
d. Stem: One- or two-piece stainless steel.
e. Disc: Stainless steel.

D. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
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; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Div.
d. DeZurik Water Controls.
e. Hammond Valve.
f. Milwaukee Valve Company.
g. Mueller Steam Specialty; a division of SPX Corporation.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Lug type; suitable for bidirectional double dead-end service at full rated pressure 2" through 12" without use of downstream flange. Field replaceable hard phenolic backed cartridge.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: NBR.
f. Stem: One- or two-piece 416 stainless steel.
g. Disc: Stainless steel.

2.5 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 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. Shurjoint Piping Products.
c. Tyco Fire Products LP; Grinnell Mechanical Products.
d. Victaulic Company.
e. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-67, Type I.
b. CWP Rating: 175 psig (1200 kPa).
c. Body Material: Coated, ductile iron.
d. Stem: Two-piece stainless steel.
e. Disc: Coated, ductile iron.
f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Kennedy Valve; a division of McWane, Inc.
   c. Mueller Steam Specialty; a division of SPX Corporation.
   d. Shurjoint Piping Products.
   e. Tyco Fire Products LP; Grinnell Mechanical Products.
   f. Victaulic Company.
   g. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
   a. Standard: MSS SP-67, Type I.
   b. NPS 8 (DN 200) and Smaller CWP Rating: 300 psig (2070 kPa).
   c. NPS 10 (DN 250) and Larger CWP Rating: 200 psig (1380 kPa).
   d. Body Material: Coated, ductile iron.
   e. Stem: Two-piece stainless steel.
   f. Disc: Coated, ductile iron.
   g. Seal: EPDM.

2.6 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Division.
      d. Conbraco Industries, Inc.; Apollo Valves.
   2. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Design: Vertical flow.
      d. Body Material: ASTM B 61 or ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

B. Class 125, Lift Check Valves with Nonmetallic Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flo Fab Inc.
      b. Hammond Valve.
      c. Kitz Corporation.
      d. Milwaukee Valve Company.
      e. Mueller Steam Specialty; a division of SPX Corporation.
      f. Red-White Valve Corporation.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      h. Conbraco Industries, Inc.; Apollo Valves.
   2. Description:
      a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: NBR, PTFE, or TFE.

2.7 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Conbraco Industries, Inc.; Apollo Valves
i. Description:
1) Standard: MSS SP-80, Type 3.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Design: Horizontal flow.
4) Body Material: ASTM B 62, bronze.
5) Ends: Threaded.
6) Disc: Bronze.

B. Class 150, Bronze Swing Check Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Milwaukee Valve Company.
e. Red-White Valve Corporation.
f. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig (2070 kPa).
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.8 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Legend Valve.
f. Milwaukee Valve Company.
g. Red-White Valve Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Conbraco Industries, Inc.; Apollo Valves.

2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
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. Conbraco Industries, Inc.; Apollo Valves.
2. Description
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Composition.
g. Seat Ring: Bronze.
h. Disc Holder: Bronze.
i. Disc: PTFE or TFE.
j. 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. Shurjoint Piping Products.
c. Tyco Fire Products LP; Grinnell Mechanical Products.
d. Victaulic Company.
2. Description:
a. CWP Rating: 300 psig (2070 kPa).

b. Body Material: ASTM A 536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring-operated, ductile iron or stainless steel.

2.10 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. Red-White Valve Corporation.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
g. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded[or solder joint].
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron[, bronze, or aluminum].

B. Class 125, 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. Crane Co.; Crane Valve Group; Stockham Division.
c. Red-White Valve Corporation.
d. Conbraco Industries, Inc.; Apollo Valves.
2. Description:
a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded[or solder joint].
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron[, bronze, or aluminum].

C. 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. Milwaukee Valve Company.

d. Red-White Valve Corporation.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
f. Conbraco Industries, Inc.; Apollo Valves.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig (2070 kPa).
   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[, bronze, or aluminum].

2.11 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Attachment: For connection to [ball] [butterfly] [and] [plug] valve stems.
   3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
   4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install chainwheels on operators for [ball] [butterfly] [and] [globe] valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

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: Ball with memory stop, circuit setter, or flow control valves.
   4. Pump-Discharge Check Valves:
      a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with [bronze] [or] [nonmetallic] disc.
      b. NPS 2-1/2 (DN 65) and Larger for Domestic Water: Brass swing check valves with lever and weight or with spring or iron, center-guided, [metal] [or] [resilient]-seat check valves.
      c. NPS 2-1/2 (DN 65) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

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

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder- joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
7. For Grooved-End [Copper Tubing] [and] [Steel Piping]: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3 (DN 100) and Smaller:
1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: [Class 125] [Class 150], [bronze] [nonmetallic] disc.
3. Ball Valves: [Two] [Three] piece, full port, bronze with brass trim.
4. Bronze Swing Check Valves: [Class 125], [bronze] [nonmetallic] disc.
5. Bronze Globe Valves: [Class 125] [Class 150], [bronze] [nonmetallic] disc.

B. Pipe NPS 4 (DN 150) and Larger:
1. Iron, Single-Flange Butterfly Valves: 200 CWP, [EPDM] [NBR] seat, [aluminum- bronze] [ductile-iron] [stainless-steel] disc.
2. Iron, Grooved-End Butterfly Valves: 300 CWP.
3. Iron Swing Check Valves: [Class 125] [Class 250], [metal] [nonmetallic-to-metal] seats.
4. Iron, Grooved-End Swing Check Valves: 300 CWP.

3.6 [SANITARY-WASTE] [AND] [STORM-DRAINAGE] VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze[and Brass] Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: [Class 125] [Class 150], [bronze] [nonmetallic] [stainless-steel] disc.
3. Ball Valves: [Two] [Three] piece, full port, [brass] [or] [bronze] with [brass] [bronze] [stainless-steel] trim.
4. Bronze Swing Check Valves: [Class 125] [Class 150], [bronze] [nonmetallic] disc.
5. Bronze Globe Valves: [Class 125] [Class 150], [bronze] [nonmetallic] disc.
6. Pipe NPS 2-1/2 (DN 65) and Larger:

B. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
1. Iron Swing Check Valves: [Class 125] [Class 250], [metal] [nonmetallic-to-metal] seats.
2. Iron, Grooved-End Swing Check Valves: 300 CWP.

END OF SECTION

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Pipe markers.

D. Ceiling tacks.

1.2 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2015.

1.3 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Air Terminal Units: Tags.

B. Dampers: Ceiling tacks, where located above lay-in ceiling.

C. Major Control Components: Nameplates.

D. Piping: Tags.

E. Pumps: Nameplates.

F. Tanks: Nameplates.

G. Thermostats: Nameplates.

H. Valves: Rivited Labels and ceiling tacks where located above lay-in ceiling.

2.2 NAMEPLATES

A. Description: Laminated three-layer plastic with engraved letters.
   1. Letter Color: White.
   2. Letter Height: 1/4 inch.

3. Background Color: Black.

2.3 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.

B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

2.4 PIPE MARKERS

A. Comply with ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

D. Color code as follows:
1. Potable, Cooling, Boiler, Feed, Other Water: Green with white letters.
2. Flammable Fluids: Yellow with black letters.

2.5 CEILING TACKS

A. Manufacturers:
1. Craftmark Pipe Markers; _____: www.craftmarkid.com/#sle.
2. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: Steel with 3/4 inch diameter color coded head.

C. Color code as follows:
1. HVAC Equipment: Yellow.
2. Fire Dampers and Smoke Dampers: Red.
3. Plumbing Valves: Green.
4. Heating/Cooling Valves: Blue.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic pipe markers in accordance with manufacturer's instructions.

D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

F. Use tags on piping 3/4 inch diameter and smaller.
   1. Identify service, flow direction, and pressure.
   2. Install in clear view and align with axis of piping.
   3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

G. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

SECTION 22 0719 - PLUMBING INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Piping system insulation.
   2. Equipment insulation.
   3. Pipe insulation jackets.
   4. Equipment insulation jackets.
   5. Insulation accessories including vapor retarders and accessories.

B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

1.2 **REQUIREMENTS**

A. All insulation shall have a maximum flame spread index of 25.

B. All insulation shall have a maximum smoke developed index of 50.

1.3 SUBMITTALS

A. Product Data: Submit product description, thermal characteristics, flame spread index, smoke developed index and list of materials and thickness for each service, and location.

1.4 CLOSE OUT SUBMITTALS

A. Not Applicable

1.5 QUALITY ASSURANCE

A. Insulation shall be installed to provide an impenetrable vapor barrier around the object insulated. The insulation contractor shall fully adhere insulation to all surfaces so that there are no gaps between the insulation and the surface of the object insulated.

B. Insulation shall not be compressed when installed upon objects. Insulator shall install insulation so that it maintains its original (specified) thickness.

C. Insulation jacketing must maintain a continuous barrier around insulation. Insulation jacketing that has cuts, rips or breaks will not be accepted.

D. Insulation jacketing must be clean and having its original reflectivity.

E. Maintain temperature before, during and after installation for a minimum of 24 hours.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

B. Maintain temperature during and after installation for minimum period of 24 hours.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.1 **INSULATION CODE**

A. MAN MADE MINERAL FIBER: Insulation Code PI-1
   1. Insulation: ASTM C457, Type I - pipe and tubing insulation
      a. Temperature ranges 0F to 850F
      b. 'K' factor: ASTM C177, 0.24 at 75 degrees F
      c. ASJ Vapor Retarder Jacket
      d. Moisture Vapor Transmission: 0.002 perm

B. MAN MADE MINERAL FIBER: Insulation Code PI-2
   1. Insulation: ASTM C1393, Type I - semi rigid fiberous glass board, Class 2
      a. Temperature ranges 0F to 850F
      b. 'K' factor: ASTM C177, 0.27 at 75 degrees F
      c. ASJ Vapor Retarder Jacket
         1) Moisture Vapor Transmission: 0.002 perm

C. CELLULAR POLYISOCYANURATE INSULATION: Insulation Code PI-3
   1. Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation: ASTM C591, Type III, compressive strength 50 psi
      a. Temperature ranges -297F to 250F
      b. 'K" factor: 0.19 at 75 degrees F.
      c. Fasteners: Fasten with fiber reinforced masking tape. For sizedover 6" fasten with18 gage stainless steel wires over fiber reinforced masking tape.

D. ELASTOMERIC CELLULAR FOAM: Insulation Code PI-4

1. Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular form: ASTM C534; Type I, Tubular form.
2. Elastomeric Foam Adhesive:
   a. Air dried, contact adhesive, compatible with insulation.

2.2 PIPE INSULATION AND EQUIPMENT JACKETS:

A. PVC Plastic Jacket: Insulation Jacket Code PJ-1
   1. Product Description: Sheet material, color coded to match piping service.
   2. Moisture Vapor Transmission: ASTM E96; 0.002 perm-inches.
      a. Thickness: 30 mil.
         1) Connections: Brush on welding adhesive.
         2) Compatible with insulation.

B. VentureClad: Insulation Jacket Code PJ-2
   1. VentureClad model 1579CW-E insulation jacketing tape with and aluminum stucco embossed finish.
      a. Stainless Steel Pipe Jacket: Insulation Jacket Code PJ-3
         1) ASTM A167 Type 304 stainless steel
         2) Thickness: 0.18 inch thick
         3) Finish: Smooth
         4) Metal Jacket Bands: 3/8” wide; 0.010 inch thick stainless steel

2.3 PUMP INSULATION:

A. All pumps insulation shall be formed into a box surrounding the pump and fabricated from polystyrene board (engineer to determine required thickness). Polystyrene board shall be covered VentureClad model 1577CW-WM tape. Edges and corners of the box shall be connected via wooden skewers and shall be sealed with and adhesive similar to Childers CP-97 Fibros Adhesive. Tape all seams and joints with FSK tape.

2.4 VALVE INSULATION:

A. All Domestic water valves shall be insulated per systems insulation requirements.

B. APPROVED INSULATION MANUFACTURERS:

2.5 ARMSTRONG

A. Certain-Teed

B. Dow Chemical

C. HiTherm

D. Johns Manville

E. Owens Corning

F. Pittsburg Corning

G. Specialty Products & Insulation

H. Venture Products

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify piping and equipment has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

A. Verify field measurements prior to fabrication.

B. Insulate entire piping system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints:
   1. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory- applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
   2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with fitting covers.

C. Inserts and Shields:
   1. Application: Piping or Equipment
   2. Shields: Minimum 12inches Long Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
   3. Insert location: Between support shield and piping and under finish jacket.
   4. Inserts (Domestic Cold Water and Rain Water Collectors): Armaflex Ultima (Wood Dowels or Wood Blocking are not allowed)
   5. Inserts (Domestic Hot Water): 12” long minimum Calcium Silicate (Wood Dowels or Wood Blocking are not allowed)

D. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent fire stopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions.

E. All vapor barrier and jacket seams shall be located located at 3 or 9 o’clock position on side of horizontal piping and with overlap facing down to shed water or on bottom side of horizontal duct.

F. Heat Traced Piping: Size insulation large enough to enclose pipe and heat tracer.

G. Factory Insulated Equipment: Do not insulate.

H. Exposed Piping and Equipment: Locate insulation and cover seams in least visible locations.

I. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

J. Finish insulation at supports, protrusions, and interruptions.

K. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.

L. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.

M. All piping routed interior to the building and in concealed spaces does not require a jacket.

3.3 SCHEDULES

A. Piping insulation required thickness based on fluid temperature and insulation conductivity:

Fluid Operating Temperature Range and Usage (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (inches)				
	Conductivity Btu * in/(h*ft2* °F)	Mean Rating Temperature, °F	< 1	1 to <1 ½	1½ to < 4	4 to < 8	≤8
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0

For piping smaller than 1.5 inch and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted, but not to a thickness less than 1 inch.

B. Pipe Insulation Schedule:
   1. Piping System / Insulation Code / Jacket Code
      a. Domestic Hot Water - Interior to Building Exposed / PI-1/ PJ-1 PJ-3*
      b. Domestic Hot Water - Interior to Building Concealed / PI-1 / None Required
      c. Domestic Cold Water - Interior to Building Exposed / PI-4 / PJ-1 PJ-3*
      d. Domestic Cold Water - Interior to Building Concealed / PI-4 / None Required
      e. Domestic Cold Water - Exterior to Building / PI-3 / PJ-2
      f. Horizontal Rain Water Conductors - Interior to Building Exposed and Concealed/ PI-4 / None Required

C. * Use stainless steel jacket if room temperature exceeds 120F and where volatile or corrosive chemicals are stored.

END OF SECTION

SECTION 22 0719.11 - UNDER-LAVATORY PIPE AND SUPPLY COVERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Under-lavatory pipe and supply covers.

1.2 RELATED REQUIREMENTS

A. Section 22 1005 - Plumbing Piping.

1.3 REFERENCE STANDARDS

A. 28 CFR 36 - Nondiscrimination by Public Accommodations and in Commercial Facilities; Final Rule; Department of Justice; current edition.

B. 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines; current edition.

C. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design; 2010.

D. ASTM C1822 - Standard Specification for Insulating Covers on Accessible Lavatory Piping; 2015.

E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.

F. ICC (IBC) - International Building Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. ICC A117.1 - Accessible and Usable Buildings and Facilities; 2017.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog illustrations of covers, sizes, and finishes.

C. Manufacturer's Instructions: Indicate installation methods and procedures.

D. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 UNDER-LAVATORY PIPE AND SUPPLY COVERS

A. Basis of Design: Plumberex Specialty Products, Inc; www.plumberex.com/#sle.
   1. Fusion Molded Under-Lavatory Insulators (Non-Sewn): Plumberex Handy-Shield Maxx.
   2. Slim Fit Under-Lavatory Insulators (Non-Sewn): Plumberex Trap Gear.
   3. Under-Lavatory Covers with Snap-Lock Fasteners (Molded): Plumberex Pro-Extreme.

B. General:
   1. Insulate exposed drainage piping including hot, cold, and tempered water supplies under lavatories or sinks per ADA Standards.
   2. Adhesives, sewing threads, and two-ply laminated materials are prohibited.
   3. Exterior Surfaces: Smooth nonabsorbent with no finger recessed indentations for easy cleaning.
   4. Construction: 1/8 inch PVC with antimicrobial, antifungal, and ultraviolet light (UV) resistant properties.
      a. Comply with ASTM C1822 for covers on accessible lavatory piping.

C. ASTM E84 Compliant, Under-Lavatory Insulators:
   1. Construction: Soft, non-laminated, flexible PVC with antimicrobial, antifungal, and UV-resistant properties. Fusion molded one piece universal design for multiple P-trap configurations. Adhesives, sewing threads, and two ply laminated materials shall not be allowed. Exterior surfaces shall be smooth nonabsorbent with no finger recessed indentations for easy cleaning. Supply riser shall be flexible and a minimum of 15 inches inches in length.
   2. Provide with weep hole for condensation drainage and ventilation.
   3. Fasteners: Reusable, fusion bonded Velcro and tamper resistant snap-locking fasteners with no sharp or abrasive external surfaces. No cable tie fasteners allowed.

D. Under-Lavatory Covers with Snap-Lock Fasteners:
   1. Manufacturers:
      a. Plumberex Specialty Products, Inc: Plumberex Pro-Extreme; www.plumberex.com/#sle.
   2. Construction: PVC with antimicrobial, antifungal, and UV-resistant properties, one piece injected molded design with internal bridge at top of J-bend to prevent separating.
   3. Fasteners: Reusable, snap-locking fasteners with no sharp or abrasive external surfaces. No cable ties allowed.
   4. Maintenance: Valve and supply cover shall be accessible for maintenance without removal and with removable, reusable access cap.
   5. Provide with weep hole for condensation drainage and ventilation.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install under-lavatory guards according to manufacturer's written instructions..

3.2 CLEANING

A. Clean installed under-lavatory guards.

3.3 PROTECTION

A. Protect installed products from damage due to subsequent construction operations.

B. Repair or replace damaged products before Date of Substantial Completion.

END OF SECTION

SECTION 22 0800 - PLUMBING SYSTEMS BASIC COMMISSIONING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. Ensure that all systems are operating in a manner consistent with the Contract Documents.

B. Execute all Basic Commissioning responsibilities assigned and include the cost of Basic Commissioning in the Contract price.
   1. Basic Commissioning of Systems does not need to be performed by a separate / specialty Commissioning Agent.

C. Plumbing Systems to be commissioned include the following:
   1. Sanitary Waste and Vent
   2. Roof and Storm Drainage
   3. Domestic Water Heaters
   4. Domestic Hot Water Circulating Pumps
   5. Domestic Cold Water Distribution
   6. Domestic Hot Water Distribution
   7. Natural Gas Distribution
   8. Plumbing Fixtures

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.4 SUBMITTALS

A. Contractor shall prepare Prefunctional Checklists and Functional Performance Test (FPT) procedures and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Owner for review and approval.

B. Contractor shall provide Owner with documentation required for Basic Commissioning Work. At minimum, documentation shall include: Detailed Start-up procedures, full sequences of operation, Operating and Maintenance data, performance data, Functional Performance Test Procedures, control drawings, and details of Owner-contracted tests.

C. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

D. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:
   1. Shop drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and A/E via the Contractor.
   2. Incorporate manufacturer's Start-up procedures with Prefunctional checklists.
   3. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.
   4. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Owner may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.
   5. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 TEST EQUIPMENT

A. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

PART 3 EXECUTION

3.1 PREPARATION

A. Construction Phase:
   1. Provide manufacturer's data sheets and shop drawing submittals of equipment.
   2. Provide additional requested documentation to the Contractor, prior to O&M manual submittals, for development of Prefunctional Checklist and Functional Performance Tests procedures.

a. Typically, this will include detailed manufacturer's installation and Start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified.
b. In addition, the installation, Start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Contractor.
c. This information and data request may be made prior to normal submittals.

3. With input from the BAS Provider and A/E, Clarify the operation and control of commissioned equipment in areas where the Specifications, BAS control drawings, or equipment documentation are not sufficient for writing detailed test procedures.
4. Prepare the specific Functional Performance Test procedures specified in Section 20 08 16. Ensure that Functional Performance Test procedures address feasibility, safety, and equipment protection and provide necessary written alarm limits to be used during the tests.
5. Develop the Commissioning Plan using manufacturer's Start-up procedures and the Prefunctional Checklists. Submit manufacturer's detailed Start-up procedures and the Commissioning Plan and procedures and other requested equipment documentation to Owner for review.
6. During the Start-up and initial checkout process, execute and document related portions of the Prefunctional Checklists for all commissioned equipment.
7. Perform and clearly document all completed Prefunctional Checklists and Start-up procedures. Provide a copy to the Owner prior to the Functional Performance Test.
8. Address current A/E and Owner punch list items before Functional Performance Tests. Air and water test, adjust and balance shall be completed with discrepancies and problems remedied before Functional Performance Tests of the respective air or water related systems are executed.
9. Provide skilled technicians to execute starting of equipment and to assist in execution of Functional Performance Tests. Ensure that they are available and present during the agreed-upon schedules and for a sufficient duration to complete the necessary tests, adjustments, and problem solving.
10. Correct deficiencies (differences between specified and observed performance) as interpreted by the Owner's Project Manager and A/E and retest the system and equipment.
11. Compile all Commissioning records and documentation to be included in a Commissioning and Closeout Manual.
12. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to actual conditions.
13. During construction, maintain Record Drawings and Specifications of all Contract Documents and Contractor-generated coordination Drawings. Update after completion of Commissioning activities (include deferred tests). The Record Drawings and Specifications shall be delivered to the Owner both in electronic format as required by the Owner.
14. Provide training of the Owner's operating personnel as specified.
15. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. Warranty Phase:
1. Execute seasonal or deferred tests, witnessed by the Owner, according to the Specifications.
a. Complete deferred tests as part of this Contract during the Warranty Period. Schedule this activity with Owner. Perform tests and document and correct deficiencies. Owner may observe the tests and review and approve test documentation and deficiency corrections.

b. If any check or test cannot be completed prior to Substantial Completion due to the building structure, required occupancy condition, or other condition, execution of such test may be delayed to later in the Warranty Period, upon approval of the Owner. Contractor shall reschedule and conduct these unforeseen deferred tests in the same manner as deferred tests.

2. Correct deficiencies and make necessary adjustments to O&M manuals, Commissioning documentation, and Record Drawings for applicable issues identified in any seasonal testing.

3.2 TESTING

A. Prefunctional Checklists and Start-up:
   1. Follow the Start-up and initial checkout procedures listed in this Section and in Division 01. Start-up and complete systems and sub-systems so they are fully functional, meeting the requirements of the Contract Documents.
   2. Prefunctional Checklists shall be complete prior to commencement of a Functional Performance test.

B. Functional Performance Tests:
   1. Functional Performance Tests are conducted after system Start-up and checkout is satisfactorily completed. Air balancing and water balancing shall be completed before Functional Performance Tests.

C. Coordination Between Testing Parties:
   1. Factory Start-ups: Factory Start-ups are specified for certain equipment. Factory Start-ups generally are Start-up related activities that will be reviewed and checked prior to Functional Performance Tests. All costs associated with factory Start-ups shall be included with the contract price unless otherwise noted. Notify the Commissioning Team of the factory Start-up schedule and coordinate these factory Start-ups with witnessing parties. The Commissioning Team members may witness these Start-ups at their discretion.
   2. Independent Testing Agencies: For systems that specify testing by an independent testing agency, the cost of the test shall be included in the Contract price unless otherwise noted. Testing performed by independent agencies may cover aspects required in the Prefunctional Checklists, Start-ups, and Functional Performance Tests. Coordinate with the independent testing agency so that Owner and/or A/E can witness the test to ensure that applicable aspects of the test meet requirements.

END OF SECTION

SECTION 22 0813 - PLUMBING SYSTEMS PREFUNCTIONAL TESTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. This Section expands on and defines responsibilities of the Contractor regarding Prefunctional Checklists and Start-up portions of the Commissioning process and addresses validation of proper and thorough installation of mechanical, plumbing and fire protection systems.

B. Contractor shall oversee the Commissioning activities with the Contractor's Subcontractors and the Architect/Engineer (A/E).

C. Contractor shall completely install, thoroughly inspect, Start-up, test, adjust and integrate air and water balance by Owner's TAB firm on systems and equipment. All activities shall be documented on specific, procedural forms developed for that purpose. Contractor shall notify A/E and Owner in writing that systems are complete and ready for verification and Functional Performance Tests.

D. Completed Prefunctional Checklists for all pieces of equipment shall be submitted to the Owner prior to Functional Performance Tests.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.4 SUBMITTALS

A. Prefunctional Checklists, Prefunctional Tests, and Start-up documents are the normal procedure of ensuring that the mechanical, plumbing, and fire protection system components are properly installed.

B. The Subcontractor in cooperation with the A/E and Contractor shall develop Prefunctional Checklists and Prefunctional Tests during the Construction Phase.

C. Completeness of Prefunctional Checklists: This Section summarizes the minimum standard for systems and equipment checkout. A record of testing and acknowledgement that a procedure has been

completed and that it checks out acceptably must be included in the Prefunctional Checklists. The Prefunctional Checklist shall identify in columnar format each device, location, test method, control sequence of operation reference, device code reported, and other data as appropriate.

D. Equipment Data Documentation: Provide completed, as-installed, specific product nameplate data, product numbers, serial numbers, etc. to fully define the asset for Owner's use in maintenance management and asset tracking. This data may be incorporated within the Equipment Matrix as described in Division 01 as a spreadsheet format or electronic database. In addition to specific manufacturer's name and specific product identifiers such as model number, serial numbers, date of manufacture, etc, the following information shall be included with the equipment data documentation:
   1. Capacity data: Where applicable, use equipment schedules on the Drawings as a guideline for fields to be used.
   2. Location identifier field for each of the three dimensions (Floor Level, X axis, and Y axis) using the Drawing column grids as the basis for location.

E. Submit the equipment data documentation with the draft Prefunctional Checklists to the Owner for approval. A/E and Owner will review the Prefunctional Checklists and request any additional information required to meet the Commissioning Plan criteria.

F. Written Certification: The Contractor shall certify that the installation, Start-up, Prefunctional Checklist, and initial operation of the system or component is in accordance with the Contract Documents, Commissioning Plan, and manufacturer's requirements, and that the system is ready for Functional Performance Tests. Any outstanding items or non-conformance shall be clearly indicated and highlighted on the Prefunctional Checklist and an action item shall have been initiated. Refer to Division 01 for specific details on non-conformance issues relating to Prefunctional Checklists.

G. Refer to Section 23 08 00 for additional documentation requirements.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. The Prefunctional Checklist procedures described in this Section provide minimum guidelines for development of Prefunctional Checklists; Start-up procedures, and Prefunctional Tests. Contractor shall prepare the Prefunctional Checklists using these procedures and that of the manufacturers and/or applicable codes and standards.

C. The Prefunctional Checklist form shall acknowledge that installation and Start-up procedures were successfully adhered to and completely performed and shall document relevant parameters (panel and equipment connections, measured values, ground faults, trip settings, etc.). When indicated as performing a checkout on multiple items or multiple procedure items, Prefunctional Checklist forms shall itemize each individual item.

PART 3 EXECUTION

3.1 PREFUNCTIONAL CHECKLIST PROCEDURES

A. Valves:
   1. Operate all manual and automatic valves through their full stoke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
   2. Verify that actuators are properly installed with adequate clearance.
   3. For automatic, pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable.

B. Meters and Gauges:
   1. Adjust faces of meters and gauges to proper angle for best visibility.
   2. Clean windows of meters and gauges, including factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gauges that require temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure that threads are clean and that connection can be easily made.
   3. Meters and gauges requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

C. Mechanical Identification:
   1. Verify that all valve tags, piping, duct, and equipment labeling corresponds with the Drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
   2. Adjusting: Relocate any mechanical identification device which has become visually blocked by Work of this Division or other Divisions.
   3. Cleaning: Clean the face of identification devices and glass frames of valve charts.

D. Piping:
   1. The following applies to all installed piping systems including underground Site utilities.
      a. Inspect all piping for proper installation, adequate support with appropriate vibration isolation where applicable, and adequate isolation valves for required service.
      b. Flush and treat all piping as appropriate to the application and clean all strainers.
      c. Ensure that adequate drainage is provided at low points and venting is provided at high points. Ensure that air is thoroughly removed from the system as applicable.
      d. Ensure that all piping is adequately supported and anchored to allow expansion. As applicable, bump across the line pumps and inspect for excessive pipe movement.
      e. Pressure and/or leak test all applicable systems in accordance with requirements in the applicable Specification Sections. Record pressure testing results and certification that piping meets the Specification and submit with the Prefunctional Checklist.
      f. Sterilize applicable piping systems as specified in the individual Specification Sections and as required by regulatory authorities. Record the results of sterilization and all parameters during this process and certify that the piping meets the Specification. Include results with Prefunctional Checklist.

g. Submit test reports that document testing results and certification of results with the Prefunctional Checklist.
h. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation. Document setting and actual trip points of all such controls.
i. Set and adjust fill, pressure, or level controls to the required setting.
j. Compare installation with mark-up Record Drawings to ensure the drawing accuracy.

E. Water Heaters:
1. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide Start-up service, and demonstrate and train Owner's personnel as specified below.
a. Check for piping per manufacturer's direction.
b. Check for leaks at piping connections.
c. Check that recirculation and control requirements are per manufacturer's recommendations.
d. Set and test relief valves and record test parameters.
e. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.
f. Record all Start-up procedures and parameters in Prefunctional Checklists.

3.2 ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

END OF SECTION

SECTION 22 1113 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for water service.

B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.2 SUBMITTALS

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

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 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. Comply with standards of authorities having jurisdiction for fire-suppression water- service piping, including materials, hose threads, installation, and testing.

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

D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.

E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire- service-main products.

F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

G. NSF Compliance:
   1. Comply with NSF 14 for plastic potable-water-service piping. Include marking "NSF- pw" on piping.
   2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.4 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution 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 water-distribution service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of service.
   2. Do not proceed with interruption of water-distribution service without Construction Manager's and Owner's written permission.

1.5 COORDINATION

A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L, water tube, annealed temper.
   1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

B. Hard Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L, water tube, drawn temper.
   1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

C. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Gaskets: AWWA C111, rubber.

E. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
   1. Grooved-End, Ductile-Iron Pipe Appurtenances:
      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) Anvil International, Inc.

2) Victaulic Company of America.

2.2 JOINING MATERIALS

A. Refer to Division 22 Section "Common Work Results for Plumbing" for commonly used joining materials.

B. Brazing Filler Metals: AWS A5.8, BCuP Series.

C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.3 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Tubular-Sleeve Pipe Couplings:
1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
a. Standard: AWWA C219.

2.4 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
a. American AVK Co.; Valves & Fittings Div.
b. American Cast Iron Pipe Co.; American Flow Control Div.
c. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
d. Crane Co.; Crane Valve Group; Stockham Div.
e. East Jordan Iron Works, Inc.
f. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
g. McWane, Inc.; Kennedy Valve Div.
h. McWane, Inc.; M & H Valve Company Div.
i. McWane, Inc.; Tyler Pipe Div.; Utilities Div.
j. Mueller Co.; Water Products Div.
k. NIBCO INC.
l. U.S. Pipe and Foundry Company.
4. Nonrising-Stem, Metal-Seated Gate Valves:
a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.

1) Standard: AWWA C500.
2) Minimum Pressure Rating: 200 psig.
3) End Connections: Mechanical joint.
4) Interior Coating: Complying with AWWA C550.

5. Nonrising-Stem, Resilient-Seated Gate Valves:
   a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
      1) Standard: AWWA C509.
      2) Minimum Pressure Rating: 200 psig.
      3) End Connections: Mechanical joint.
      4) Interior Coating: Complying with AWWA C550.
6. Nonrising-Stem, High-Pressure, Resilient-Seated Gate Valves:
   a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.
      1) Standard: AWWA C509.
      2) Minimum Pressure Rating: 250 psig.
      3) End Connections: Push on or mechanical joint.
      4) Interior Coating: Complying with AWWA C550.
7. OS&Y, Rising-Stem, Metal-Seated Gate Valves:
   a. Description: Cast- or ductile-iron body and bonnet, with cast-iron double disc, bronze disc and seat rings, and bronze stem.
      1) Standard: AWWA C500.
   b. Minimum Pressure Rating: 200 psig.
      1) End Connections: Flanged.
8. OS&Y, Rising-Stem, Resilient-Seated Gate Valves:
   a. Description: Cast- or ductile-iron body and bonnet, with bronze or gray- or ductile-iron gate, resilient seats, and bronze stem.
      1) Standard: AWWA C509.
      2) Minimum Pressure Rating: 200 psig.
      3) End Connections: Flanged.

B. UL/FMG, Cast-Iron Gate Valves:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. American Cast Iron Pipe Co.; American Flow Control Div.
      b. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
      c. Crane Co.; Crane Valve Group; Stockham Div.
      d. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
      e. McWane, Inc.; Kennedy Valve Div.
      f. McWane, Inc.; M & H Valve Company Div.
      g. Mueller Co.; Water Products Div.
      h. NIBCO INC.

i. U.S. Pipe and Foundry Company.

4. UL/FMG, Nonrising-Stem Gate Valves:
   a. Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.
      1) Standards: UL 262 and FMG approved.
      2) Minimum Pressure Rating: 175 psig.
      3) End Connections: Flanged.
5. OS&Y, Rising-Stem Gate Valves:
   a. Description: Iron body and bonnet and bronze seating material.
      1) Standards: UL 262 and FMG approved.
      2) Minimum Pressure Rating: 175 psig.
      3) End Connections: Flanged.

C. Bronze Gate Valves:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Div.
      d. Hammond Valve.
      e. Milwaukee Valve Company.
      f. NIBCO INC.
      g. Red-White Valve Corporation.
   4. OS&Y, Rising-Stem Gate Valves:
      a. Description: Bronze body and bonnet and bronze stem.
         1) Standards: UL 262 and FMG approved.
         2) Minimum Pressure Rating: 175 psig.
         3) End Connections: Threaded.
   5. Nonrising-Stem Gate Valves:
      a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.
         1) Standard: MSS SP-80.

2.5 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.

b. East Jordan Iron Works, Inc.
c. Flowserve.
d. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
e. McWane, Inc.; Kennedy Valve Div.
f. McWane, Inc.; M & H Valve Company Div.
g. Mueller Co.; Water Products Div.
h. U.S. Pipe and Foundry Company.

4. Description: Sleeve and valve compatible with drilling machine.
   a. Standard: MSS SP-60.
   b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
   c. Valve: AWWA, cast-iron, nonrising-stem, resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches in diameter.
   1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.6 CORPORATION VALVES AND CURB VALVES

A. Manufacturers:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amcast Industrial Corporation; Lee Brass Co.
      b. Ford Meter Box Company, Inc. (The); Pipe Products Div.
      c. Jones, James Company.
      d. Master Meter, Inc.
      e. McDonald, A. Y. Mfg. Co.
      f. Mueller Co.; Water Products Div.
      g. Red Hed Manufacturing & Supply.

B. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.
   1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
   2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
   3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.

C. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

D. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches in diameter.
   1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.7 WATER METERS

A. Water meters will be furnished by utility company.

B. Manufacturers:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. AMCO Water Metering Systems.
      b. Badger Meter, Inc.
      c. Carlon Meter.
      d. Hays Fluid Controls; a division of ROMAC Industries Inc.
      e. McCrometer.
      f. Mueller Co.; Hersey Meters.
      g. Neptune Technology Group Inc.
      h. Sensus Metering Systems.

C. Displacement-Type Water Meters:
   1. Description: With bronze main case.
      a. Standard: AWWA C700.
      b. Registration: Flow in cubic meters.

D. Compound-Type Water Meters:
   1. Description:
      a. Standard: AWWA C702.
      b. Registration: Flow in cubic meters.

2.8 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   a. Ames Fire & Waterworks; a division of Watts Regulator Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Flomatic Corporation.
   e. Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Wilkins Water Control Products Div.
4. Standard: ASSE 1013 or AWWA C511.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
7. Size: as per drawings.
8. Design Flow Rate: as per drawings.
9. Selected Unit Flow Range Limits: as per drawings
10. Pressure Loss at Design Flow Rate: as per drawings for NPS 2 and smaller; as per drawings for NPS 2-1/2 and larger.
11. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
12. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
13. Configuration: Designed for horizontal, straight through flow.
14. Accessories:
    a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
    b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

B. Double-Check, Backflow-Prevention Assemblies:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; a division of Watts Regulator Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Watts Water Technologies, Inc.
      f. Zurn Plumbing Products Group; Wilkins Water Control Products Div.
   3. Standard: ASSE 1015 or AWWA C510.
   4. Operation: Continuous-pressure applications, unless otherwise indicated.
   5. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   6. Size: as per drawings
   7. Design Flow Rate: as per drawings
   8. Selected Unit Flow Range Limits: as per drawings
   9. Pressure Loss at Design Flow Rate: as per drawings for NPS 2 and smaller; as per drawings for NPS 2-1/2 and larger.
   10. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.

11. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
12. Configuration: Designed for horizontal, straight through flow.
13. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

2.9 WATER METER BOXES

A. Description: Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" in cover; and with slotted, open-bottom base section of length to fit over service piping.
   1. Option: Base section may be cast-iron, PVC, clay, or other pipe.

B. Description: Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" in top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.

C. Description: Polymer-concrete body and cover for disc-type water meter, with lettering "WATER" in cover; and with slotted, open-bottom base section of length to fit over service piping. Include vertical and lateral design loadings of 15,000 lb minimum over 10 by 10 inches square.

2.10 CONCRETE VAULTS

A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.
   1. Ladder: ASTM A 36/A 36M, steel or polyethylene-encased steel steps.
   2. Manhole: ASTM A 48/A 48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
      a. Dimension: 24-inch minimum diameter, unless otherwise indicated.
   3. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron traffic frame and cover.
      a. Dimension: 24-inch- minimum diameter, unless otherwise indicated.
   4. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.11 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. American AVK Co.; Valves & Fittings Div.
      b. American Cast Iron Pipe Co.; American Flow Control Div.
      c. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
      d. American Foundry Group, Inc.
      e. East Jordan Iron Works, Inc.
      f. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).

g. McWane, Inc.; Kennedy Valve Div.
h. McWane, Inc.; M & H Valve Company Div.
i. Mueller Co.; Water Products Div.
j. Troy Valve; a division of Penn-Troy Manufacturing, Inc.
k. U.S. Pipe and Foundry Company.

4. Description: Freestanding, with one NPS 4-1/2 and two NPS 2-1/2 outlets, 5-1/4-inch main valve, drain valve, and NPS 6 mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
   a. Standard: AWWA C502.
   b. Pressure Rating: 250 psig.
5. Description: Freestanding, with one NPS 4-1/2 and two NPS 2-1/2 outlets, 5-1/4-inch main valve, drain valve, and NPS 6 mechanical-joint inlet. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
   a. Standards: UL 246, FMG approved.
   b. Pressure Rating: 250 psig.
   c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
   d. Operating and Cap Nuts: Pentagon, 1-1/2 inches point to flat.
   e. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
   f. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated. PART 3 - EXECUTION

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

E. Underground water-service piping NPS 3/4 to NPS 3 shall be soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

F. Underground water-service piping NPS 4 and NPS 6 shall be any of the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

2. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.

G. Water Meter Box Water-Service Piping NPS 3/4 to NPS 2 shall be same as underground water- service piping.

H. Aboveground and Vault Water-Service Piping NPS 3/4 to NPS 3 shall be hard copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

I. Aboveground and vault water-service piping NPS 4 and NPS 6 shall be any of the following:
   1. Hard copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
   2. Ductile-iron, grooved-end pipe; ductile-iron, grooved-end appurtenances; and grooved joints.

J. Aboveground and Vault Fire-Service-Main Piping NPS 4 to NPS 8 shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

K. Underground Combined Water-Service and Fire-Service-Main Piping NPS 6 to NPS 10 shall be any of the following:
   1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

L. Aboveground and Vault Combined Water Service and Fire-Service-Main Piping NPS 6 to NPS 10 shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Underground Valves, NPS 3 and Larger: AWWA, cast-iron, nonrising-stem, high-pressure, resilient-seated gate valves with valve box.
   2. Underground Valves, NPS 4 and Larger, for Indicator Posts: UL/FMG, cast-iron, nonrising-stem gate valves with indicator post.
   3. Use the following for valves in vaults and aboveground:
      a. Gate Valves, NPS 2 and Smaller: Bronze, nonrising stem.
      b. Gate Valves, NPS 3 and Larger: AWWA, cast iron, OS&Y rising stem, resilient seated.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

A. See Division 22 Section "Common Work Results for Plumbing" for piping-system common requirements.

3.5 PIPING INSTALLATION

A. Materials within plenums shall be noncombustible or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723.

B. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

C. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

D. Make connections larger than NPS 2 with tapping machine according to the following:
   1. Install tapping sleeve and tapping valve according to MSS SP-60.
   2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
   3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.

E. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
   1. Make connections NPS 2 and smaller with drilling machine according to the following:
   2. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
   3. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
   4. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
   5. Install corporation valves into service-saddle assemblies.
   6. Install manifold for multiple taps in water main.
   7. Install curb valve in water-service piping with head pointing up and with service box.

F. Comply with NFPA 24 for fire-service-main piping materials and installation.
   1. Install copper tube and fittings according to CDA's "Copper Tube Handbook."

G. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

H. Install PE pipe according to ASTM D 2774 and ASTM F 645.

I. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.

J. Bury piping with depth of cover over top at least 30 inches.

K. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

L. Sleeves are specified in Division 22 Section "Common Work Results for Plumbing."

M. Mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

N. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

3.6 JOINT CONSTRUCTION

A. See Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.

B. Make pipe joints according to the following:
1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
2. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
3. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved- end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
4. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
5. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
6. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure. Refer to Division 22 Section "Common Work Results for Plumbing" for joining piping of dissimilar metals.

3.7 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
1. Concrete thrust blocks.
2. Locking mechanical joints.
3. Set-screw mechanical retainer glands.
4. Bolted flanged joints.
5. Heat-fused joints.
6. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
3. Fire-Service-Main Piping: According to NFPA 24.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

C. MSS Valves: Install as component of connected piping system.

D. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.9 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to utility company's written instructions.

B. Water Meters: Install displacement-type water meters, NPS 2 and smaller, in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets and valved bypass around meters unless prohibited by authorities having jurisdiction.

C. Water Meters: Install compound-type water meters, NPS 3 and larger, in meter vaults. Include shutoff valves on water meter inlets and outlets and valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.

3.10 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.11 WATER METER BOX INSTALLATION

A. Install water meter boxes in paved areas flush with surface.

B. Install water meter boxes in grass or earth areas with top 2 inches above surface.

3.12 CONCRETE VAULT INSTALLATION

A. Install precast concrete vaults according to ASTM C 891.

3.13 FIRE HYDRANT INSTALLATION

A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.

B. Wet-Barrel Fire Hydrants: Install with valve below frost line. Provide for drainage.

C. AWWA Fire Hydrants: Comply with AWWA M17.

D. UL/FMG Fire Hydrants: Comply with NFPA 24.

3.14 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install protective pipe bollards on three sides of each fire department connection. Pipe bollards are specified in Division 05 Section "Metal Fabrications."

3.15 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. See Division 22 Section "Common Work Results for Plumbing" for piping connections to valves and equipment.

C. Connect water-distribution piping to utility water main. Use tapping sleeve and tapping valve or service clamp and corporation valve as required on drawings.

D. Connect water-distribution piping to interior domestic water piping.

E. Connect waste piping from concrete vault drains to sanitary sewerage system. See Division 22 Section "Facility Sanitary Sewers" for connection to sanitary-sewer piping.

3.16 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
   1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.17 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving."

B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Division 22 Section "Common Work Results for Plumbing" for identifying devices.

3.18 CLEANING

A. Clean and disinfect water-distribution piping as follows:
   1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
   2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
   3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
      a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
      b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
      c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

END OF SECTION

SECTION 22 1116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Specialty valves.
3. Flexible connectors.
4. Water meters furnished by utility company for installation by Contractor.
5. Water meters.
6. Escutcheons.
7. Sleeves and sleeve seals.

1.2 RELATED SECTION:

A. Division 221113 Section "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.

C. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L drawn temper.
   1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
   2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
   4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and- socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
   5. Copper Pressure-Seal-Joint Fittings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Elkhart Products Corporation; Industrial Division.
         2) NIBCO INC.
         3) Viega; Plumbing and Heating Systems.
      b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
      c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
   6. Copper Push-on-Joint Fittings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) NVent LLC.
      b. Description: Cast-copper fitting complying with ASME B16.18 or wrought- copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.

B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.
   1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   2. Copper Pressure-Seal-Joint Fittings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Elkhart Products Corporation; Industrial Division.
         2) NIBCO INC.
         3) Viega; Plumbing and Heating Systems.
      b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
      c. NPS 3 and NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O- ring seal in each end.

2.3 PIPING JOINING MATERIALS

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

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, 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 general- duty brazing unless otherwise indicated.

2.4 SPECIALTY VALVES

A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.5 TRANSITION FITTINGS

A. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

B. Sleeve-Type Transition Coupling: AWWA C219.

C. Plastic-to-Metal Transition Fittings:
1. Description: CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket or threaded end.

D. Plastic-to-Metal Transition Unions:
1. Description: CPVC or PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Description:
a. Pressure Rating: 250 psig at 180 deg F.
b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Description:
a. Factory-fabricated, bolted, companion-flange assembly.
b. Pressure Rating: 175 psig minimum.
c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder- joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
1. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:
1. Description:
a. Galvanized-steel coupling.
b. Pressure Rating: 300 psig at 225 deg F.
c. End Connections: Female threaded.
d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:
1. Description:
a. Electroplated steel nipple complying with ASTM F 1545.
b. Pressure Rating: 300 psig at 225 deg F.
c. End Connections: Male threaded or grooved.
d. Lining: Inert and noncorrosive, propylene.

2.7 FLEXIBLE CONNECTORS

A. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
1. Working-Pressure Rating: Minimum 250 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

B. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
1. Working-Pressure Rating: Minimum 250 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.8 WATER METERS

A. Displacement-Type Water Meters:
1. Description:
a. Standard: AWWA C700.
b. Pressure Rating: 150-psig working pressure.
c. Body Design: Nutating disc; totalization meter.
d. Registration: In gallons or cubic feet as required by utility.
e. Case: Bronze.
f. End Connections: Threaded.

B. Compound-Type Water Meters:

1. Description:
   a. Standard: AWWA C702.
   b. Pressure Rating: 150-psig working pressure.
   c. Body Design: With integral mainline and bypass meters; totalization meter.
   d. Registration: In gallons or cubic feet as required by utility company.
   e. Case: Bronze.
   f. Pipe Connections: Flanged.

C. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

2.9 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated or rough-brass finish with setscrews.

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

D. One Piece, Stamped Steel: Chrome-plated finish with setscrew or spring clips.

E. Split Casting, Cast Brass: Polished, chrome-plated or rough-brass finish with concealed hinge and setscrew.

F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew or spring clips.

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

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

2.10 SLEEVES

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

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

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

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

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

2.11 SLEEVE SEALS

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

2.12 GROUT

A. Standard: ASTM C 1107, 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 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

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

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

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

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

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

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

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

I. Install seismic restraints on piping. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

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 adjacent to equipment and specialties to allow service and maintenance.

N. Install piping to permit valve servicing.

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

P. Install piping free of sags and bends.

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

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

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

T. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

U. Install thermometers on outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

3.3 JOINT CONSTRUCTION

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

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

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

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

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

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

F. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

H. 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.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

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

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. **Use ball valves only for piping NPS 3 and smaller**. Use butterfly valves for piping NPS 4 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

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

C. Transition Fittings in Aboveground Domestic Water PipingNPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 to NPS 6: Use dielectric flange kits.

3.7 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.8 WATER METER INSTALLATION

A. Rough-in domestic water piping for water meter installation, and install water meters according to utility company's requirements.

B. Water meters will be furnished and installed by utility company.

C. Install water meters according to AWWA M6, utility company's requirements, and the following:

D. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.

E. Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.

F. Install remote registration system according to standards of utility company and of authorities having jurisdiction.

3.9 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. 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. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1 and Smaller: 36 inches with 3/8-inch rod.
   2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.

J. Install supports for vertical CPVC piping every 60 inches for NPS 1 and smaller, and every 72 inches for NPS 1-1/4 and larger.

K. Install vinyl-coated hangers for PEX piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.

L. Install hangers for vertical PEX piping every 48 inches.

M. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
   2. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6: 48 inches with 3/4-inch rod.

N. Install supports for vertical PVC piping every 48 inches.

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

3.10 CONNECTIONS

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

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

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

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
   4. 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.

3.11 ESCUTCHEON INSTALLATION

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

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome- plated finish cast brass with rough-brass finish.
5. Bare Piping in Equipment Rooms: One piece, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:
1. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2. Insulated Piping: Split plate, stamped steel with concealed hinge and spring clips.
3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
5. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish.
6. Bare Piping in Equipment Rooms: Split casting, cast brass.
7. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.12 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

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

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

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:
   1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
   2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
      a. Extend sleeves 2 inches above finished floor level.
      b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
   3. Sleeves for Piping Passing through Gypsum-Board Partitions:
      a. Steel pipe sleeves for pipes smaller than NPS 6.
      b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
      c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
   4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
   5. Sleeves for Piping Passing through Exterior Concrete Walls:
      a. Steel pipe sleeves for pipes smaller than NPS 6.
      b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
      c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

L. 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 in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.13 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.14 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.15 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
   1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   2. Test for leaks and defects in new piping 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.
   3. 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.
   4. 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.
   5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
   6. Prepare reports for tests and for corrective action required.

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

E. Prepare test and inspection reports.

3.16 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

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

3.17 PIPING SCHEDULE

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

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

C. Under-building-slab, domestic water, building service piping, NPS 3 and smaller, shall be one of the following:
1. Soft copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints.

D. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 6, shall be one of the following:
1. Push-on-joint, ductile-iron pipe; standard- or compact- pattern push-on-joint fittings; and gasketed joints.

E. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be one of the following:
1. Hard 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 one of the following:
1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L or ASTM B 88, Type M; copper pressure-seal- joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B 88, Type L or ASTM B 88, Type M; copper push-on-joint fittings; and push-on joints.
4. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints.

G. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:
1. Hard copper tube, ASTM B 88, Type L ASTM B 88, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L or ASTM B 88, pressure-seal- joint fittings; and pressure-sealed joints.

H. Aboveground domestic water piping, NPS 5 and NPS 6, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and soldered joints.

3.18 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: Memory-stop balancing valves.
      a. 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.

D. CPVC and PVC valves matching piping materials may be used.

END OF SECTION

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following domestic water piping specialties:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Water pressure-reducing valves.
   4. Balancing valves.
   5. Temperature-actuated water mixing valves.
   6. Hot Water Return Automatic Balancing Valve
   7. Strainers.
   8. Hose bibbs.
   9. Wall hydrants.
   10. Drain valves.
   11. Water hammer arresters.
   12. Trap-seal primer valves.

B. See Division 22 Section "Domestic Water Piping" for water meters.

C. See Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

D. See Division 22 Section "Domestic Water Filtration Equipment" for water filters in domestic water piping.

1.2 PERFORMANCE REQUIREMENTS

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

1.3 SUBMITTALS

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

B. Field quality-control test reports.

C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. NSF Compliance:
   1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. FEBCO; SPX Valves & Controls.
      e. Rain Bird Corporation.
      f. Toro Company (The); Irrigation Div.
      g. Watts Industries, Inc.; Water Products Div.
      h. Zurn Plumbing Products Group; Wilkins Div.
      i. Standard: ASSE 1001.
      j. Size: NPS 1/4 to NPS 3, as required to match connected piping.
      k. Body: Bronze.
      l. Inlet and Outlet Connections: Threaded.
      m. Finish: Rough bronze.
   3. Hose-Connection Vacuum Breakers:
      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) Arrowhead Brass Products, Inc.
         2) Cash Acme.
         3) Conbraco Industries, Inc.
         4) Legend Valve.
         5) MIFAB, Inc.
         6) Prier Products, Inc.
         7) Watts Industries, Inc.; Water Products Div.
         8) Woodford Manufacturing Company.
         9) Zurn Plumbing Products Group; Light Commercial Operation.
         10) Zurn Plumbing Products Group; Wilkins Div.
      c. Standard: ASSE 1001.
      d. Body: Bronze, nonremovable, with manual drain.
      e. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
      f. Finish: Rough bronze.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Honeywell Water Controls.
   e. Legend Valve.
   f. Watts Industries, Inc.; Water Products Div.
   g. Zurn Plumbing Products Group; Wilkins Div.
3. Standard: ASSE 1012.
4. Operation: Continuous-pressure applications.
5. Size: NPS 3/4.
6. Body: Bronze.
7. End Connections: Solder joint.
8. Finish: Rough bronze.

B. Reduced-Pressure-Principle Backflow Preventers:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Plumbing Products Group; Wilkins Div.
   4. Standard: ASSE 1013.
   5. Operation: Continuous-pressure applications.
   6. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
   7. Size: as per drawings
   8. Design Flow Rate: as per drawings
   9. Selected Unit Flow Range Limits: as per drawings
   10. Pressure Loss at Design Flow Rate: as per drawings for sizes NPS 2 and smaller; as per drawings for NPS 2-1/2 and larger.
   11. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   12. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   13. Configuration: Designed for horizontal, straight through flow.
   14. Accessories:
      a. Valves: Ball type with threaded ends on inlet and outlet ofNPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2- 1/2 and larger.
      b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Double-Check Backflow-Prevention Assemblies:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Plumbing Products Group; Wilkins Div.
   4. Standard: ASSE 1015.
   5. Operation: Continuous-pressure applications, unless otherwise indicated.
   6. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   7. Size: as per drawings
   8. Design Flow Rate: as per drawings
   9. Selected Unit Flow Range Limits: as per drawings
   10. Pressure Loss at Design Flow Rate: as per drawings for sizes NPS 2 and smaller; as per drawings for NPS 2-1/2 and larger.
   11. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   12. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   13. Configuration: Designed for horizontal, straight through flow.
   14. Accessories:
      a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2- 1/2 and larger.

D. Backflow-Preventer Test Kits:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
      c. Flomatic Corporation.
      d. Watts Industries, Inc.; Water Products Div.
      e. Zurn Plumbing Products Group; Wilkins Div.
   4. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test- procedure instructions.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. Honeywell Water Controls.
   d. Watts Industries, Inc.; Water Products Div.
   e. Zurn Plumbing Products Group; Wilkins Div.
3. Standard: ASSE 1003.
4. Pressure Rating: Initial working pressure of 150 psig.
5. Size: as per drawings
6. Design Flow Rate: as per drawings
7. Design Inlet Pressure: as per drawings
8. Design Outlet Pressure Setting: as per drawings
9. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
10. Valves for Booster Heater Water Supply: Include integral bypass.
11. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.4 BALANCING VALVES

A. Memory-Stop Balancing Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corp.
3. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
4. Pressure Rating: 400-psig minimum CWP.
5. Size: NPS 2 or smaller.
6. Body: Copper alloy.
7. Port: Standard or full port.
8. Ball: Chrome-plated brass.
9. Seats and Seals: Replaceable.
10. End Connections: Solder joint or threaded.

11. Handle: Vinyl-covered steel with memory-setting device.

2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Armstrong International, Inc.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. Honeywell Water Controls.
      e. Legend Valve.
      f. Leonard Valve Company.
      g. Powers; a Watts Industries Co.
      h. Symmons Industries, Inc.
      i. Taco, Inc.
      j. Watts Industries, Inc.; Water Products Div.
      k. Zurn Plumbing Products Group; Wilkins Div.
   4. Standard: ASSE 1017.
   5. Pressure Rating: 125 psig.
   6. Type: Thermostatically controlled water mixing valve.
   7. Material: Bronze body with corrosion-resistant interior components.
   8. Connections: Threaded union inlets and outlet.
   9. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature- control handle.
   10. Tempered-Water Setting: 105°F
   11. Tempered-Water Design Flow Rate: as per drawings
   12. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Armstrong International, Inc.
      b. Lawler Manufacturing Company, Inc.
      c. Leonard Valve Company.
      d. Powers; a Watts Industries Co.
      e. Symmons Industries, Inc.
   4. Standard: ASSE 1017.
   5. Pressure Rating: 125 psig.

6. Type: Exposed-mounting, thermostatically controlled water mixing valve.
7. Material: Bronze body with corrosion-resistant interior components.
8. Connections: Threaded union inlets and outlet.
9. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
10. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
11. Tempered-Water Setting: 105 °F
12. Tempered-Water Design Flow Rate: as per drawings
13. Selected Valve Flow Rate at 45-psig Pressure Drop: as per drawings
14. Pressure Drop at Design Flow Rate: as per drawings
15. Valve Finish: Rough bronze.
16. Piping Finish: Copper.
17. Cabinet: Factory-fabricated, stainless steel, for recessed mounting and with hinged, stainless-steel door.

2.6 HOT WATER RETURN AUTOMATIC BALANCING VALVES

A. Furnish and install CIRCUITSOLVER® UNION ASSEMBLY as indicated on the plans. CIRCUITSOLVER® UNION ASSEMBLY shall be self-contained and fully automatic without additional piping or control mechanisms. Thermostatic valve shall be a CIRCUITSOLVER® as manufactured by ThermOmegaTech®, Inc., or equivalent.
   1. CIRCUITSOLVER® shall regulate the flow of recirculated domestic hot water based on water temperature entering the CIRCUITSOLVER® UNION ASSEMBLY regardless of system operating pressure. As the water temperature increases the valve proportionally closes dynamically adjusting flow to meet the specified temperature.
      a. CIRCUITSOLVER® never fully closes, even at the desired set point. There is always sufficient bypass flow back to the recirculating pump to prevent overheating or “dead heading” of the pump.
      b. CIRCUITSOLVER® is set at the factory for the desired return temperature. No field adjustments. Several temperature set points are available.
      c. CIRCUITSOLVER® UNION ASSEMBLY shall be available in ½”, ¾”, & 1” with FNPT at both ends.

B. All components in the CIRCUITSOLVER® UNION ASSEMBLY are made with lead free materials. The major components that make up the CIRCUITSOLVER® are constructed of type 303 SS.
   1. CIRCUITSOLVER® UNION ASSEMBLY shall be rated to 200 PSIG maximum working pressure.
      a. CIRCUITSOLVER® UNION ASSEMBLY shall be standard tapered female pipe thread, NPT.
   2. CIRCUITSOLVER® UNION ASSEMBLY shall be rated to 250°F (121.1°C) maximum working temperature.
   3. CIRCUITSOLVER® UNION ASSEMBLY shall have all lead free components.
   4. Thermal actuator shall be spring loaded and self-cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits.

C. Installation of CIRCUITSOLVER® UNION ASSEMBLY shall be made by qualified tradesmen. Install CIRCUITSOLVER® UNION ASSEMBLY in each domestic hot water return piping branch beyond last hot water device in that branch.

1. Provide suitable strainer as indicated in piping detail shown on the drawings.
2. Provide suitable access panel as required in non-accessible ceilings and walls.
3. Pay close attention to flow arrow, especially with valves that have an integrated check valve.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations, unless otherwise indicated.
   5. Perforation Size:
      a. Strainers NPS 2 and Smaller: 0.020 inch.
      b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
      c. Strainers NPS 5 and Larger: 0.10 inch.
   6. Drain: Factory-installed, hose-end drain valve.

2.8 HOSE BIBBS

A. Hose Bibbs:

   1. Standard: ASME A112.18.1 for sediment faucets.
   2. Body Material: Bronze.
   3. Seat: Bronze, replaceable.
   4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
   5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
   6. Pressure Rating: 125 psig.
   7. Vacuum Breaker: Integral or field-installation, nonremovable, hose drainable, connection vacuum breaker complying with ASSE 1011.
   8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
   9. Finish for Service Areas: Rough bronze.
   10. Finish for Finished Rooms: Chrome or nickel plated.
   11. Operation for Equipment Rooms: Wheel handle or operating key.
   12. Operation for Service Areas: Operating key.
   13. Operation for Finished Rooms: Operating key.
   14. Include operating key with each operating-key hose bibb.
   15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Josam Company.
b. MIFAB, Inc.
c. Prier Products, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Woodford Manufacturing Company.
h. Zurn Plumbing Products Group; Light Commercial Operation.
i. Zurn Plumbing Products Group; Specification Drainage Operation.

3. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
4. Pressure Rating: 125 psig.
5. Operation: Loose key.
6. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Inlet: NPS 3/4 or NPS 1.
8. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
9. Box: Deep, flush mounting with cover.
10. Box and Cover Finish: Polished nickel bronze.
11. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
12. Nozzle and Wall-Plate Finish: Polished nickel bronze.
13. Operating Keys(s): Two with each wall hydrant.

B. Vacuum Breaker Wall Hydrants:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Arrowhead Brass Products, Inc.
b. Mansfield Plumbing Products LLC.
c. McDonald, A. Y. Mfg. Co.
d. Prier Products, Inc.
e. Smith, Jay. R. Mfg. Co.; Division of Smith Industries, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Woodford Manufacturing Company.
h. Zurn Plumbing Products Group; Light Commercial Operation.
3. Standard: ASSE 1019, Type A or Type B.
4. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
5. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
6. Pressure Rating: 125 psig.
7. Operation: Loose key.
8. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
9. Inlet: NPS 1/2 or NPS 3/4.
10. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.10 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
   1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
   2. Pressure Rating: 400-psig minimum CWP.
   3. Size: NPS 3/4.
   4. Body: Copper alloy.
   5. Ball: Chrome-plated brass.
   6. Seats and Seals: Replaceable.
   7. Handle: Vinyl-covered steel.
   8. Inlet: Threaded or solder joint.
   9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMTROL, Inc.
      b. Josam Company.
      c. MIFAB, Inc.
      d. PPP Inc.
      e. Sioux Chief Manufacturing Company, Inc.
      f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      g. Tyler Pipe; Wade Div.
      h. Watts Drainage Products Inc.
      i. Zurn Plumbing Products Group; Specification Drainage Operation.
   3. Standard: ASSE 1010 or PDI-WH 201.
   4. Type: Metal bellows.
   5. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.12 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. MIFAB, Inc.
      b. PPP Inc.
      c. Sioux Chief Manufacturing Company, Inc.
      d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      e. Watts Industries, Inc.; Water Products Div.
   3. Standard: ASSE 1018.

4. Pressure Rating: 125 psig minimum.
5. Body: Bronze.
6. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
7. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
8. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

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

C. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

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

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

F. Install Y-pattern strainers for water on supply side of each control valve, water pressure- reducing valve, solenoid valve, and pump.

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

H. 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.

I. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

J. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Intermediate atmospheric-vent backflow preventers.

2. Reduced-pressure-principle backflow preventers.
3. Double-check backflow-prevention assemblies.
4. Water pressure-reducing valves.
5. Primary, thermostatic, water mixing valves.
6. Supply-type, trap-seal primer valves.

K. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
   1. Test each reduced-pressure-principle backflow preventer and double-check backflow- prevention assembly according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.3 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow of balancing valves.

C. SET FIELD-ADJUSTABLE TEMPERATURE SET POINTS OF TEMPERATURE-ACTUATED WATER MIXING VALVES.

END OF SECTION

SECTION 22 1122 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Service meters.
7. Concrete bases.

1.3 DEFINITIONS

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

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
1. Piping and Valves: 150 psig (1035 kPa) minimum unless otherwise indicated.
2. Service Regulators: 100 psig (690 kPa) minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: [5 psig (34.5 kPa)] [10 psig (69 kPa)] [20 psig (138 kPa)] [65 psig (450 kPa)].

B. Natural-Gas System Pressure within Buildings: [0.5 psig (3.45 kPa) or less] [More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa)] [More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa)].

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Corrugated, stainless-steel tubing with associated components.
   3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   4. Pressure regulators. Indicate pressure ratings and capacities.
   5. Service meters. Indicate[pressure ratings and] capacities. Include [bypass fittings] [bypass fittings and meter bars] [meter bars] [supports].
   6. Dielectric fittings.

B. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of seismic restraints.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified professional engineer.

B. Welding certificates.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [motorized gas valves] [pressure regulators] [and] [service meters] to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

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

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

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

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

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

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.10 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify the Owner no fewer than seven days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without the Owner's written permission.

1.11 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      a. Material Group: 1.1.
      b. End Connections: Threaded or butt welding to match pipe.
      c. Lapped Face: Not permitted underground.
      d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
      e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

1) Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   (a) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
2) Mechanical Couplings:
   (a) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      (1) Dresser Piping Specialties; Division of Dresser, Inc.
      (2) Smith-Blair, Inc.
   (b) [Stainless-steel] [Steel] flanges and tube with epoxy finish.
   (c) Buna-nitrile seals.
   (d) [Stainless-steel] [Steel] bolts, washers, and nuts.
   (e) Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
   (f) Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

f. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   (a) Parker Hannifin Corporation; Parflex Division.
   (b) Titeflex.
   (c) Gastite.
2) Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
3) Coating: PE with flame retardant.
   (a) 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] [450] or less.
4) Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
5) Striker Plates: Steel, designed to protect tubing from penetrations.
6) Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
7) Operating-Pressure Rating: 5 psig (34.5 kPa).

B. PE Pipe: ASTM D 2513, SDR 11.
1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.
   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.

b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.[Vent casing aboveground.]
c. Aboveground Portion: PE transition fitting.
d. Outlet shall be threaded or flanged or suitable for welded connection.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.
   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
   b. Outlet shall be threaded or flanged or suitable for welded connection.
   c. Bridging sleeve over mechanical coupling.
   d. Factory-connected anode.
   e. Tracer wire connection.
   f. Ultraviolet shield.
   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
5. Plastic Mechanical Couplings,NPS 1-1/2 (DN 40) and Smaller: Capable of joining PE pipe to PE pipe.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Lyall, R. W. & Company, Inc.
      2) Mueller Co.; Gas Products Div.
      3) Perfection Corporation; a subsidiary of American Meter Company.
   b. PE body with molded-in, stainless-steel support ring.
   c. Buna-nitrile seals.
   d. Acetal collets.
   e. Electro-zinc-plated steel stiffener.
6. Plastic Mechanical Couplings,NPS 2 (DN 50) and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Lyall, R. W. & Company, Inc.
      2) Mueller Co.; Gas Products Div.
      3) Perfection Corporation; a subsidiary of American Meter Company.
   b. Fiber-reinforced plastic body.
   c. PE body tube.
   d. Buna-nitrile seals.
   e. Acetal collets.
   f. Stainless-steel bolts, nuts, and washers.
7. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Dresser Piping Specialties; Division of Dresser, Inc.

2) Smith-Blair, Inc.
b. [Stainless-steel] [Steel] flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. [Stainless-steel] [Steel] bolts, washers, and nuts.
e. Factory-installed anode for steel-body couplings installed underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. T-Pattern Strainers:
1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. 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.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
1. CWP Rating: 150 psig (1035 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
1. CWP Rating: 150 psig (1035 kPa).
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. BrassCraft Manufacturing Company; a Masco company.
   b. Conbraco Industries, Inc.; Apollo Div.
   c. Lyall, R. W. & Company, Inc.

d. McDonald, A. Y. Mfg. Co.
e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Three-Piece, Full-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BrassCraft Manufacturing Company; a Masco company.
b. Conbraco Industries, Inc.; Apollo Div.
c. Lyall, R. W. & Company, Inc.
d. McDonald, A. Y. Mfg. Co.
e. Perfection Corporation; a subsidiary of American Meter Company.
2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Bronze Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Lee Brass Company.
b. McDonald, A. Y. Mfg. Co.
c. Perfection Corporation; a subsidiary of American Meter Company.
d. Conbraco Industries, Inc.; Apollo Div.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa).

7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. McDonald, A. Y. Mfg. Co.
   b. Mueller Co.; Gas Products Div.
   c. Xomox Corporation; a Crane company.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flowserve.
   b. Homestead Valve; a division of Olson Technologies, Inc.
   c. McDonald, A. Y. Mfg. Co.
   d. Milliken Valve Company.
   e. Mueller Co.; Gas Products Div.
   f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

I. PE Ball Valves: Comply with ASME B16.40.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Kerotest Manufacturing Corp.
   b. Lyall, R. W. & Company, Inc.

c. Perfection Corporation; a subsidiary of American Meter Company.
2. Body: PE.
3. Ball: PE.
4. Stem: Acetal.
5. Seats and Seals: Nitrile.
6. Ends: Plain or fusible to match piping.
7. CWP Rating: 80 psig (552 kPa).
8. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
9. Operator: Nut or flat head for key operation.
10. Include plastic valve extension.
11. Include tamperproof locking feature for valves where indicated on Drawings.

J. Valve Boxes:
1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ASCO Power Technologies, LP; Division of Emerson.
b. Dungs, Karl, Inc.
c. Eaton Corporation; Controls Div.
d. Eclipse Combustion, Inc.
e. Honeywell International Inc.
f. Johnson Controls.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. Normally closed.
6. Visual position indicator.
7. [Electrical] [Mechanical] operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ASCO Power Technologies, LP; Division of Emerson.
b. Dungs, Karl, Inc.
c. Eclipse Combustion, Inc.
d. Goyen Valve Corp.; Tyco Environmental Systems.
e. Magnatrol Valve Corporation.
f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.

g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Visual position indicator.

2.6 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Vanguard Valves, Inc.
   2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   3. Maximum Operating Pressure: 5 psig (34.5 kPa).
   4. Cast-aluminum body with nickel-plated chrome steel internal parts.
   5. Nitrile-rubber valve washer.
   6. Sight windows for visual indication of valve position.
   7. Threaded end connections complying with ASME B1.20.1.
   8. Wall mounting bracket with bubble level indicator.

B. Earthquake Valves: Comply with ASCE 25.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   2. Pacific Seismic Products, Inc.
   3. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   4. Maximum Operating Pressure: [0.5 psig (3.45 kPa)] [7 psig (48 kPa)] [60 psig (414 kPa)].
   5. Cast-aluminum body with stainless-steel internal parts.
   6. Nitrile-rubber, reset-stem o-ring seal.
   7. Valve position, open or closed, indicator.
   8. Composition valve seat with clapper held by spring or magnet locking mechanism.
   9. Level indicator.
   10. End Connections: Threaded for valves NPS 2 (DN 50) and smaller; flanged for valves NPS 2-1/2 (DN 65) and larger.

2.7 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.

4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Actaris.
      b. American Meter Company.
      c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
      d. Invensys.
      e. Richards Industries; Jordan Valve Div.
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
   8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
   10. Overpressure Protection Device: Factory mounted on pressure regulator.
   11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
   12. Maximum Inlet Pressure: 100 psig (690 kPa).

C. Line Pressure Regulators: Comply with ANSI Z21.80.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Actaris.
      b. American Meter Company.
      c. Eclipse Combustion, Inc.
      d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
      e. Invensys.
      f. Maxitrol Company.
      g. Richards Industries; Jordan Valve Div.
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
   8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
   10. Overpressure Protection Device: Factory mounted on pressure regulator.

11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: [2 psig (13.8 kPa)] [5 psig (34.5 kPa)] [10 psig (69 kPa)].

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Canadian Meter Company Inc.
   b. Eaton Corporation; Controls Div.
   c. Harper Wyman Co.
   d. Maxitrol Company.
   e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: [1 psig (6.9 kPa)] [2 psig (13.8 kPa)] [5 psig (34.5 kPa)].

2.8 SERVICE METERS

A. Diaphragm-Type Service Meters: Comply with [ANSI B109.1] [ANSI B109.2].
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris.
   b. American Meter Company.
   c. Invensys.
2. Case: Die-cast aluminum.
3. Connections: Steel threads.
4. Diaphragm: Synthetic fabric.
5. Diaphragm Support Bearings: Self-lubricating.
6. Compensation: Continuous temperature[and pressure].
7. Meter Index: [Cubic feet] [Liters] [Cubic feet and liters].
8. Meter Case and Index: Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig (690 kPa).
11. Pressure Loss: Maximum [0.5-inch wg (124 Pa)] [2.0-inch wg (498 Pa)].
12. Accuracy: Maximum plus or minus 1.0 percent.

B. Rotary-Type Service Meters: Comply with ANSI B109.3.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Meter Company.
   b. Invensys.
2. Case: Extruded aluminum.

3. Connection: Flange.
4. Impellers: Polished aluminum.
5. Rotor Bearings: Self-lubricating.
6. Compensation: Continuous temperature[and pressure].
7. Meter Index: [Cubic feet] [Liters] [Cubic feet and liters].
8. Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig (690 kPa).
11. Accuracy: Maximum plus or minus 2.0 percent.

C. Turbine Meters: Comply with ASME MFC-4M.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Meter Company.
   b. Invensys.
2. Housing: Cast iron or welded steel.
3. Connection Threads or Flanges: Steel.
4. Turbine: Aluminum or plastic.
5. Turbine Bearings: Self-lubricating.
6. Compensation: Continuous temperature[and pressure].
7. Meter Index: [Cubic feet] [Liters] [Cubic feet and liters].
8. Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig (690 kPa).
11. Accuracy: Maximum plus or minus 2.0 percent.

D. Service-Meter Bars:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris.
   b. American Meter Company.
   c. Lyall, R. W. & Company, Inc.
   d. McDonald, A. Y. Mfg. Co.
   e. Mueller Co.; Gas Products Div.
   f. Perfection Corporation; a subsidiary of American Meter Company.
2. Malleable- or cast-iron frame for supporting service meter.
3. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
4. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

E. Service-Meter Bypass Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Lyall, R. W. & Company, Inc.
   b. Williamson, T. D., Inc.
2. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
3. Integral ball-check bypass valve.

2.9 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. Capitol Manufacturing Company.
      b. Central Plastics Company.
      c. Hart Industries International, Inc.
      d. Jomar International Ltd.
      e. Matco-Norca, Inc.
      f. McDonald, A. Y. Mfg. Co.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      h. Wilkins; a Zurn company.
   2. Description:
      a. Standard: ASSE 1079.
      b. Pressure Rating: [125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [250 psig (1725 kPa)].
      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, Inc.
      d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      e. Wilkins; a Zurn company.
   2. Description:
      a. Standard: ASSE 1079.
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: [125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [175 psig (1200 kPa)] [300 psig (2070 kPa)].
      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: 150 psig (1035 kPa).

c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

2.10 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to [NFPA 54] [the International Fuel Gas Code] to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with [NFPA 54] [the International Fuel Gas Code] requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with [NFPA 54] for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:
1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Replace pipe having damaged PE coating with new pipe.

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

F. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with [NFPA 54] for installation and purging of natural-gas piping.

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

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

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

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

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

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
   1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
   2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
   3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
   4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
      a. Exception: Tubing passing through partitions or walls does not require striker barriers.
   5. Prohibited Locations:
      a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
      b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

W. 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."

X. 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."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground[, on concrete bases].

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.8 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).

D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 PAINTING

A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI EXT 5.1D.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
      c. Topcoat: Exterior alkyd enamel [(flat)] [(semigloss)] [(gloss)].
      d. Color: Comply with [NFPA 54] [the International Fuel Gas Code].

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      a. Prime Coat: [Alkyd anticorrosive] [Quick-drying alkyd] metal primer.
      b. Intermediate Coat: Interior latex matching topcoat.
      c. Topcoat: Interior latex [(flat)] [(low sheen)] [(eggshell)] [(satin)] [(semigloss)] [(gloss)].
      d. Color: Comply with [NFPA 54] [the International Fuel Gas Code].
   2. Alkyd System: MPI INT 5.1E.
      a. Prime Coat: [Alkyd anticorrosive] [Quick-drying alkyd] metal primer.
      b. Intermediate Coat: Interior alkyd matching topcoat.
      c. Topcoat: Interior alkyd [(flat)] [(eggshell)] [(semigloss)] [(gloss)].

d. Color: Comply with [NFPA 54] [the International Fuel Gas Code].

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base[according to seismic codes at Project].
1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000-psig (20.7-MPa), 28-day, compressive-strength concrete and reinforcement as specified in [Section 033000 "Cast-in-Place Concrete."] [Section 033053 "Miscellaneous Cast-in-Place Concrete."]

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
1. Test, inspect, and purge natural gas according to [NFPA 54] [the International Fuel Gas Code] and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.14 DEMONSTRATION

A. Engage a factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain earthquake valves.

3.15 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:
1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Wrap and coat pipe and fittings with protective coating for steel piping.
3. [Annealed] [Drawn]-temper copper tube with wrought-copper fittings and brazed joints. Coat and sleave pipe and fittings with protective coating for copper tubing.

B. Aboveground natural-gas piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints. Paint with corrosion prevention paint.
   2. Steel pipe with wrought-steel fittings and welded joints. Paint with corrosion prevention paint.
   3. [Annealed] [Drawn]-temper copper tube with wrought-copper fittings and brazed or flared joints. Provide damage prevention fencing around piping.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and [brazed] [flared] joints. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 KPA)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller limited to specialty equipment shall be one of the following:
   1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
   2. Annealed-temper, copper tube with wrought-copper fittings and [brazed] [flared] joints.
   3. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.17 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 KPA) AND LESS THAN 5 PSIG (34.5 KPA)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
   1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
   2. Annealed-temper, copper tube with wrought-copper fittings and [brazed] [flared] joints.
   3. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with steel welding fittings and welded joints.

C. Underground, below building, piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.18 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 5 PSIG (34.5 KPA)

A. Aboveground Piping: Maximum operating pressure more than 5 psig (34.5 kPa).

B. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.

C. Aboveground, distribution piping shall be one of the following:
   1. Steel pipe with steel welding fittings and welded joints.
   2. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

D. Underground, below building, piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

E. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

F. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.19 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground:
   1. PE valves.
   2. NPS 2 (DN 50) and Smaller: Bronze plug valves.
   3. NPS 2-1/2 (DN 65) and Larger: Cast-iron, [lubricated] [nonlubricated] plug valves.

3.20 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, [nonlubricated] [lubricated] plug valve.

E. Valves in branch piping for single appliance shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

END OF SECTION

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following soil and waste, sanitary drainage and vent piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.

B. See Division 22 Section "Chemical-Waste Systems for Laboratory and Healthcare Facilities" for chemical-waste and vent piping systems.

1.2 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.

1.3 QUALITY ASSURANCE

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

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; and "NSF-drain" for plastic drain piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.
   1. Gaskets: ASTM C 564, rubber.

B. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 or CISPI 301.
   1. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
   2. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion- resistant fasteners, and rubber sleeve with integral, center pipe stop.
      a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
      b. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

C. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Schedule 40, galvanized. Include ends matching joining method.
   1. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.
   2. Pressure Fittings:

a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
b. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
c. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
d. Cast-Iron Flanges: ASME B16.1, Class 125.
e. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

D. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought-copper, solder-joint fittings.

E. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40, solid wall.
1. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
2. Solvent Cement and Adhesive Primer:
a. Use ABS solvent cement that has a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
2. Solvent Cement and Adhesive Primer:
a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Special pipe fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

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

C. Aboveground, soil, waste, and vent piping NPS 4 and smaller shall beany of the following:
1. Service class, hub-and-spigot, cast-iron soil pipe and fittings; gaskets; and compression joints.
2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
3. Steel pipe, drainage fittings, and threaded joints.
4. Copper DWV tube, copper drainage fittings, and soldered joints.
5. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
6. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

D. Aboveground, soil, waste, and vent piping NPS 5 and larger shall beany of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and compression joints.
   2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Copper DWV tube, copper drainage fittings, and soldered joints.
   5. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
   6. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

E. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
   1. Service class, hub-and-spigot, cast-iron soil pipe and fittings; gaskets; and compression joints.
   2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
   4. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

F. Underground, soil and waste Piping NPS 5 and larger shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and compression joints.
   2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
   3. ABS pipe, ABS socket fittings, and solvent-cemented joints.
   4. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
   5. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.2 PIPING INSTALLATION

A. Materials within plenums shall be noncombustible or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723.
   1. PVC piping is not to be installed in plenum spaces

B. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."

C. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 22 Section "Common Work Results for Plumbing."

G. 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."

H. 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 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

I. 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.

J. 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.

K. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

L. Install ABS soil and waste drainage and vent piping according to ASTM D 2661.

M. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.

N. Install underground ABS and PVC soil and waste drainage piping according to ASTM D 2321.

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

3.3 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.

2. Hubless Joints: Make with rubber gasket and sleeve or clamp.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free- alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

D. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.4 VALVE INSTALLATION

A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

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

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

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Backwater valves are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:
a. 100 Feet 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. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 60 inches with 3/4-inch rod.
   5. 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 steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. 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 to NPS 5: 10 feet with 1/2-inch rod.
   5. NPS 6: 10 feet with 5/8-inch rod.

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

L. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
   2. NPS 3: 48 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6: 48 inches with 3/4-inch rod.

M. Install supports for vertical ABS and PVC piping every 48 inches.

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

B. 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. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
   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. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.7 FIELD QUALITY CONTROL

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

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

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction.
   1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   2. Prepare reports for tests and required corrective action.

3.8 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.

3.9 PROTECTION

A. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION

SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Backwater valves.
   2. Cleanouts.
   3. Floor drains.
   4. Trench drains
   5. Lint Interceptor
   6. Roof flashing assemblies.
   7. Miscellaneous sanitary drainage piping specialties.
   8. Flashing materials.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.3 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   4. Standard: ASME A112.14.1.
   5. Size: Same as connected piping.
   6. Body: Cast iron.
   7. Cover: Cast iron with bolted or threaded access check valve.
   8. End Connections: Hub and spigot.

9. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
10. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field- installed cleanout at floor; replaces backwater valve cover.

B. Drain-Outlet Backwater Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Josam Div.
   b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.
3. Size: Same as floor drain outlet.
4. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
5. Check Valve: Removable ball float.
6. Inlet: Threaded.
7. Outlet: Threaded or spigot.

2.2 CLEANOUTS

A. Exposed Cast-Iron Cleanouts:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
5. Size: Same as connected drainage piping
6. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
7. Closure: Countersunk or raised-head, brass plug.
8. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   a. Josam Company; Josam Div.
   b. Oatey.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Zurn Plumbing Products Group; Light Commercial Operation.
   h. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
5. Size: Same as connected branch.
6. Type: Threaded, adjustable housing.
7. Body or Ferrule: Cast iron.
8. Clamping Device: Required.
9. Outlet Connection: Spigot.
10. Closure: Brass plug with straight threads and gasket.
11. Adjustable Housing Material: Cast iron with threads.
12. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
13. Frame and Cover Shape: Round or Square as per drawings.
14. Top Loading Classification: Extra Heavy Duty.
15. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Standard: ASME A112.36.2M. Include wall access.
5. Size: Same as connected drainage piping.
6. Body: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
7. Closure: Countersunk or raised-head, drilled-and-threaded brass plug.
8. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
9. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
10. Wall Access: Round or Square as per drawings, nickel-bronze, copper-alloy, or stainless- steel wall-installation frame and cover.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Commercial Enameling Co.
      b. Josam Company; Josam Div.
      c. MIFAB, Inc.
      d. Prier Products, Inc.
      e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      f. Tyler Pipe; Wade Div.
      g. Watts Drainage Products Inc.
      h. Zurn Plumbing Products Group; Light Commercial Operation.
      i. Zurn Plumbing Products Group; Specification Drainage Operation.
   4. Standard: ASME A112.6.3 with backwater valve.
   5. Pattern: Area drain.
   6. Body Material: Gray iron.
   7. Seepage Flange: Not required.
   8. Anchor Flange: Required.
   9. Clamping Device: Required.
   10. Outlet: Bottom or side.
   11. Backwater Valve: Integral, ASME A112.14.1, swing-check type.
   12. Coating on Interior and Exposed Exterior Surfaces: Not required.
   13. Sediment Bucket: Insert description.
   14. Top or Strainer Material: Bronze.
   15. Top of Body and Strainer Finish: Rough bronze.
   16. Top Shape: Round or Square as per drawings.
   17. Top Loading Classification: Extra Heavy-Duty.
   18. Funnel: Not required.
   19. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   20. Trap Material: Bronze.
   21. Trap Pattern: Standard P-trap.
   22. Trap Features: Cleanout and trap-seal primer valve drain connection.

2.4 TRENCH DRAINS

A. Trench Drain
   1. Zurn Z884-SVF Trench Drain System
      a. Polypropylene modular channel section
      b. 4 3/4" wide

c. 40" long
d. Outlet Adapters as required for installation
e. Heel-Proof Polyethylene Grate - Class A
f. Stainless Steel Lockdown Hardware
g. with Stainless Steel Veneer on all exposed edges

2.5 LINT INTERCEPTOR

A. Rockford Model RLS-20 all-welded 1/4" steel separators 4" tapped inlet and outlet with tapped internal vent connection, visible double-wall outside trap seal, easily removable stainless steel filters for cleaning, removable 3/8" nonskid Aluminum diamond treadplate cover(s) for flush-with-floor installation suitable for pedestrian traffic, sealed with heavy-duty leakproof gasket, secured with stainless steel flat head screws, OPEX® Shop Coat coating inside and bituminous coating outside for flush-with-floor installation.
1. with Integral Extension to grade

2.6 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
a. Acorn Engineering Company; Elmdor/Stoneman Div.
b. Thaler Metal Industries Ltd.

B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch- thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
1. Open-Top Vent Cap: Without cap.
2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.7 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:
1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
a. NPS 2: 4-inch- minimum water seal.
b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.
   5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:
   1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
   2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:
   1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
   2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:
   1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
   2. Size: Same as connected stack vent or vent stack.

2.8 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
   3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Fasteners: Metal compatible with material and substrate being fastened.

C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

D. Solder: ASTM B 32, lead-free alloy.

E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

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

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

F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
      c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1- inch total depression.
   3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

G. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

H. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

I. Assemble open drain fittings and install with top of hub 1 inch above floor.

J. Install deep-seal traps on floor drains and other waste outlets, if indicated.

K. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.

L. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

M. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

N. Install vent caps on each vent pipe passing through roof.

O. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.
   1. Above-Floor Installation: Set unit with bottom resting on floor, unless otherwise indicated.
   2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
   3. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.
   4. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

3.6 PLACE PLUGS IN ENDS OF UNCOMPLETED PIPING AT END OF EACH DAY OR WHEN WORK STOPS.

END OF SECTION

SECTION 22 3000 - PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Water Heaters:
   1. Commercial gas fired.

B. In-line circulator pumps.

1.2 RELATED REQUIREMENTS

A. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.

B. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittals procedures.

B. Product Data:
   1. Indicate pump type, capacity, power requirements.
   2. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
   3. Provide electrical characteristics and connection requirements.

C. Shop Drawings:
   1. Indicate heat exchanger dimensions, size of tappings, and performance data.
   2. Indicate dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tappings, and drains.

D. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

E. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.

1.5 QUALITY ASSURANCE

A. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

B. Performance: Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.7 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

B. Provide five year manufacturer warranty for domestic water heaters.

PART 2 PRODUCTS

2.1 WATER HEATERS

A. Manufacturers:
1. A.O. Smith Water Products Co: www.hotwater.com/#sle.
2. Bradford White.
3. Substitutions: See Section 01 6000 - Product Requirements.

B. Commercial Gas Fired:
1. Type: Automatic, natural gas-fired, vertical storage.
2. Performance: See Drawings
3. Tank: Glass lined welded steel ASME labeled; multiple flue passages, 4 inch diameter inspection port, thermally insulated with minimum 2 inches glass fiber, encased in corrosion-resistant steel jacket; baked-on enamel finish; floor shield and legs.
4. Accessories:
   a. Water Connections: Brass.
   b. Dip Tube: Brass.
   c. Drain valve.
   d. Anode: Magnesium.
5. Certified For The Following Applications:
   a. Automatic storage water heater.
6. Controls: Automatic water thermostat with temperature range adjustable from 120 to 180 degrees F, automatic reset high temperature limiting thermostat factory set at 195 degrees F, gas pressure regulator, multi-ribbon or tubular burner, 100 percent safety shut-off pilot and thermocouple, flue baffle and draft hood.

2.2 IN-LINE CIRCULATOR PUMPS

A. Manufacturers:
   1. Taco : www.taco-hvac.com.
   2. Substitutions: See Section 01 6000 - Product Requirements.

B. Casing: Bronze, rated for 125 psig working pressure, with stainless steel rotor assembly.

C. Impeller: Bronze.

D. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.

E. Seal: Carbon rotating against a stationary ceramic seat.

F. Drive: Flexible coupling.

G. Performance: See Drawings for Model information

PART 3 EXECUTION

3.1 INSTALLATION

A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certification, if any.

B. Coordinate with plumbing piping and related fuel piping work to achieve operating system.

C. Pumps:
   1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

END OF SECTION

SECTION 22 4000 - PLUMBING FIXTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Water closets.

B. Lavatories.

C. Sinks.

D. Service sinks.

E. Under-lavatory pipe supply covers.

F. Drinking fountains.

G. Showers.

1.2 REFERENCE STANDARDS

A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design; 2010.

B. ASME A112.18.9 - Protectors/Insulators for Exposed Waste and Supplies on Accessible Fixtures; 2011.

C. ASTM C1822 - Standard Specification for Insulating Covers on Accessible Lavatory Piping; 2015.

D. ASME A112.6.1M - Supports for Off-the-Floor Plumbing Fixtures for Public Use; 1997 (Reaffirmed 2017).

E. ASME A112.18.1 - Plumbing Supply Fittings; 2018.

F. ASME A112.19.2 - Ceramic Plumbing Fixtures; 2013.

G. ASME A112.19.5 - Flush Valves and Spuds for Water Closets, Urinals, and Tanks; 2017.

H. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices; 2015.

I. ICC A117.1 - Accessible and Usable Buildings and Facilities; 2017.

J. NSF 61 - Drinking Water System Components - Health Effects; 2017.

K. NSF 372 - Drinking Water System Components - Lead Content; 2016.

1.3 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

C. Maintenance Data: Include fixture trim exploded view and replacement parts lists.

D. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Faucet Washers: One set of each type and size.
   3. Flush Valve Service Kits: One for each type and size.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept fixtures on site in factory packaging. Inspect for damage.

B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.6 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Potable Water Systems: Provide plumbing fittings and faucets that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

2.2 TANK TYPE WATER CLOSETS

A. Tank Type Water Closet Manufacturers:
   1. American Standard, Inc: www.americanstandard-us.com/#sle.
   2. Kohler Company: www.kohler.com/#sle.
   3. Zurn Industries, Inc: www.zurn.com/#sle.
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Bowl: ASME A112.19.2; floor mounted, siphon jet, vitreous china, 16.5 inches high, close-coupled closet combination with elongated rim, insulated vitreous china closet tank with fittings and lever flushing valve, bolt caps, vandalproof cover locking device. See Drawings for specific Model Information

C. Seat Manufacturers:
   1. American Standard, Inc: www.americanstandard-us.com/#sle.

2. Bemis Manufacturing Company: www.bemismfg.com/#sle.
3. Zurn Industries.
4. Substitutions: See Section 01 6000 - Product Requirements.

D. Seat: Solid white plastic, open front, extended back, less cover, complete with self-sustaining hinge.

E. Handle Height: 44 inches or less.

2.3 WALL HUNG URINALS

A. Wall Hung Urinal Manufacturers:
1. American Standard, Inc: www.americanstandard-us.com/#sle.
2. Gerber Plumbing Fixtures LLC: www.gerberonline.com/#sle.
3. Kohler Company: www.kohler.com/#sle.
4. Zurn Industries, Inc: www.zurn.com/#sle.
5. Substitutions: See Section 01 6000 - Product Requirements.

B. Urinals: Vitreous china, ASME A112.19.2, wall hung with side shields and concealed carrier. See Drawings for specific Model Information
1. Flush Volume: 1.0 gallons, maximum.
2. Flush Valve: Exposed (top spud).
3. Flush Operation: Sensor operated.
4. Trap: Integral.

C. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.
1. Sensor-Operated Type: Solenoind or motor-driven operator, low voltage hard-wired, infrared sensor with mechanical over-ride or over-ride push button.
2. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.

2.4 LAVATORIES

A. Lavatory Manufacturers: See Drawings for Basis of Design Product
1. American Standard Inc: www.americanstandard.com.
2. Kohler Company: www.kohler.com/#sle.
3. Zurn Industries, Inc: www.zurn.com/#sle.
4. Substitutions: See Section 01 6000 - Product Requirements.

B. Supply Faucet Manufacturers: See Drawings for Basis of Design Product
1. American Standard Inc: www.americanstandard.com.
2. Kohler Company: www.kohler.com/#sle.
3. Zurn Industries, Inc: www.zurn.com/#sle.
4. Speakman: www.speakmancompany.com.
5. Substitutions: See Section 01 6000 - Product Requirements.

C. Accessories:
1. Offset waste with perforated open strainer.

2. Carrier:
   a. Manufacturers:
      1) JOSAM Company; _____: www.josam.com/#sle.
      2) Zurn Industries, Inc; _____: www.zurn.com/#sle.
      3) Substitutions: See Section 01 6000 - Product Requirements.
   b. ASME A112.6.1M; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded studs for fixture hanger, bearing plate and studs.

2.5 UNDER-LAVATORY PIPE SUPPLY COVERS

A. Basis of Design: Plumberex Specialty Products, Inc; www.plumberex.com/#sle.
   1. Fusion Molded Under-Lavatory Insulators (Non-Sewn): Plumberex Handy-Shield Maxx.
   2. Slim Fit Under-Lavatory Insulators (Non-Sewn): Plumberex Trap Gear.
   3. Under-Lavatory Covers with Snap-Lock Fasteners (Molded): Plumberex Pro-Extreme.

B. General:
   1. Insulate exposed drainage piping including hot, cold and tempered water supplies under lavatories or sinks per ADA Standards.
   2. Construction: 1/8 inch PVC with antimicrobial, antifungal and UV resistant properties.
      a. Comply with ASTM C1822 Type III for covers on accessible lavatory piping.
      b. Comply with ASME A112.18.9 for covers on accessible lavatory piping.
      c. Comply with ICC A117.1.
   3. Fasteners: Reusable, snap-locking fasteners with no sharp or abrasive external surfaces. No cable ties allowed.

2.6 SHOWERS

A. Shower Manufacturers: See Drawings for Basis of Design Product

2.7 DRINKING FOUNTAINS

A. Drinking Fountain Manufacturers:
   1. Elkay Manufacturing Company: www.elkay.com/#sle.
   2. Halsey Taylor: www.halseytaylor.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Fountain: See Drawings for specific Model Information

2.8 SERVICE SINKS

A. Service Sink Manufacturers: See Drawings for Specific Model information

B. Trim: ASME A112.18.1 exposed wall type supply with cross handles, spout wall brace, vacuum breaker, hose end spout, strainers, eccentric adjustable inlets, integral screwdriver stops with covering caps and adjustable threaded wall flanges.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

B. Verify that electric power is available and of the correct characteristics.

C. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

3.2 PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.3 INSTALLATION

A. Install each fixture with trap, easily removable for servicing and cleaning.

B. Provide chrome plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.

C. Install components level and plumb.

D. Install and secure fixtures in place with wall supports and bolts.

3.4 ADJUSTING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.5 CLEANING

A. Clean plumbing fixtures and equipment.

3.6 PROTECTION

A. Protect installed products from damage due to subsequent construction operations.

B. Repair or replace damaged products before Date of Substantial Completion.

END OF SECTION

SECTION 23 0517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe sleeves.

B. Manufactured sleeve-seal systems.

1.2 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 23 0553 - Identification for HVAC Piping and Equipment: Piping identification.

C. Section 23 0716 - HVAC Equipment Insulation.

D. Section 23 0719 - HVAC Piping Insulation.

1.3 REFERENCE STANDARDS

A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2016.

B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2013a (Reapproved 2017).

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.

B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.6 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 PIPE SLEEVES

A. Manufacturers:
   1. Flexicraft Industries; Pipe Wall Sleeve: www.flexicraft.com/#sle.
   2. Substitutions: See Section 01 6000 - Product Requirements.

B. Vertical Piping:
   1. Sleeve Length: 1 inch above finished floor.
   2. Provide sealant for watertight joint.

C. Plastic or Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.

D. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:
   1. Galvanized steel pipe or black iron pipe with asphalt coating.
   2. Connect sleeve with floor plate except in mechanical rooms.

E. Clearances:
   1. Provide allowance for insulated piping.
   2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
   3. All Rated Openings: Caulked tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 8400 to prevent the spread of fire, smoke, and gases.

2.2 MANUFACTURED SLEEVE-SEAL SYSTEMS

A. Manufacturers:
   1. Flexicraft Industries; PipeSeal: www.flexicraft.com/#sle.
   2. Substitutions: See Section 01 6000 - Product Requirements.

B. Modular/Mechanical Seal:
   1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
   2. Provide watertight seal between pipe and wall/casing opening.
   3. Elastomer element size and material in accordance with manufacturer's recommendations.
   4. Glass reinforced plastic pressure end plates.

PART 3 EXECUTION

3.1 INSTALLATION

A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.

B. Install piping to conserve building space, to not interfere with use of space and other work.

C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

D. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
   1. Aboveground Piping:
      a. Pack solid using mineral fiber in compliance with ASTM C592.
      b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
   2. All Rated Openings: Caulk tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 8400 to prevent the spread of fire, smoke, and gases.

E. Manufactured Sleeve-Seal Systems:
   1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
   2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
   3. Locate piping in center of sleeve or penetration.
   4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
   5. Tighten bolting for a water-tight seal.
   6. Install in accordance with manufacturer's recommendations.

F. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.2 CLEANING

A. Upon completion of work, clean all parts of the installation.

B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Pipe markers.

D. Ceiling tacks.

1.2 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2015.

1.3 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Product Data: Provide manufacturers catalog literature for each product required.

E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

F. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Air Handling Units: Nameplates.

B. Air Terminal Units: Tags.

C. Control Panels: Nameplates.

D. Major Control Components: Nameplates.

E. Piping: Tags.

F. Pumps: Nameplates.

G. Tanks: Nameplates.

H. Valves: Tags and ceiling tacks where located above lay-in ceiling.

I. Water Treatment Devices: Nameplates.

2.2 MANUFACTURERS

A. Brady Corporation: www.bradycorp.com.

B. Champion America, Inc: www.Champion-America.com.

C. Seton Identification Products: www.seton.com/aec.

D. Substitutions: See Section 01 6000 - Product Requirements.

2.3 NAMEPLATES

A. Description: Laminated three-layer plastic with engraved letters.
   1. Letter Color: White.
   2. Letter Height: 1/4 inch.
   3. Background Color: Black.

2.4 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.

B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

C. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

D. All above ceiling equipment to be identified with tags rivieted to the ceiling grid

2.5 PIPE MARKERS

A. Color: Comply with ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

2.6 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

B. Color code as follows:
   1. HVAC Equipment: Yellow.
   2. Fire Dampers and Smoke Dampers: Red.
   3. Heating/Cooling Valves: Blue.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic pipe markers in accordance with manufacturer's instructions.

D. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

E. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

F. Identify control panels and major control components outside panels with plastic nameplates.

G. Identify thermostats relating to terminal boxes or valves with nameplates.

H. Identify valves in main and branch piping with tags.

I. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of refrigerating systems.

C. Measurement of final operating condition of HVAC systems.

1.2 RELATED REQUIREMENTS

A. Section 01 4000 - Quality Requirements: Employment of testing agency and payment for services.

1.3 REFERENCE STANDARDS

A. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2008.

B. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems; 2015, with Errata (2017).

C. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2002.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to DEDC, LLC.
   2. Include at least the following in the plan:
      a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      c. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      d. Final test report forms to be used.
      e. Detailed step-by-step procedures for TAB work for each system and issue, including:
         1) Terminal flow calibration (for each terminal type).
         2) Diffuser proportioning.
         3) Branch/submain proportioning.
         4) Total flow calculations.
         5) Rechecking.
         6) Diversity issues.
      f. Expected problems and solutions, etc.

g. Details of how TOTAL flow will be determined; for example:
   1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
   2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
h. Confirmation of understanding of the outside air ventilation criteria under all conditions.
i. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
j. Procedures for formal deficiency reports, including scope, frequency and distribution.

C. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
   1. Revise TAB plan to reflect actual procedures and submit as part of final report.
   2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for DEDC, LLC and for inclusion in operating and maintenance manuals.
   3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
   4. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
   5. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.
   6. Include the following on the title page of each report:
      a. Name of Testing, Adjusting, and Balancing Agency.
      b. Address of Testing, Adjusting, and Balancing Agency.
      c. Telephone number of Testing, Adjusting, and Balancing Agency.
      d. Project name.
      e. Project location.
      f. Project Engineer.
      g. Project Contractor.
      h. Report date.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. TAB contractor shall review all of the drawings with special attention to the controls drawings as there is additional instruction on the drawings and sequence of operation as to how balancing shall be performed and what information the controls contractor is required to obtain.

B. TAB contractor shall perform ductwork leak tests prior to installation of ceiling. TAB contractor shall schedule this work thru the mechanical contractor.

C. Perform total system balance in accordance with one of the following:
   1. SMACNA (TAB).

D. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

E. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

F. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
   2. Certified by one of the following:
      a. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.

G. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Fans are rotating correctly.
   7. Fire and volume dampers are in place and open.
   8. Air coil fins are cleaned and combed.
   9. Access doors are closed and duct end caps are in place.
   10. Air outlets are installed and connected.
   11. Duct system leakage is minimized.
   12. Hydronic systems are flushed, filled, and vented.
   13. Pumps are rotating correctly.
   14. Proper strainer baskets are clean and in place.
   15. Service and balance valves are open.

B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to DEDC, LLC to facilitate spot checks during testing.

3.4 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.5 RECORDING AND ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.6 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

3.7 SCOPE

A. Test, adjust, and balance the following:
   1. Fire Pumps.
   2. Plumbing Pumps.
   3. VRF Systems
   4. Packaged Roof Top Heating/Cooling Units.
   5. Make-up Air Units
   6. Fans.

7. Air Filters.
8. Air Inlets and Outlets.

3.8 MINIMUM DATA TO BE REPORTED

A. Electric Motors:
1. Manufacturer.
2. Model/Frame.
3. HP/BHP.
4. Phase, voltage, amperage; nameplate, actual, no load.
5. RPM.
6. Service factor.
7. Sheave Make/Size/Bore.

B. V-Belt Drives:
1. Identification/location.
2. Required driven RPM.
3. Driven sheave, diameter and RPM.
4. Belt, size and quantity.
5. Motor sheave diameter and RPM.
6. Center to center distance, maximum, minimum, and actual.

C. Pumps:
1. Identification/number.
2. Manufacturer.
3. Size/model.
4. Impeller.
5. Service.
6. Design flow rate, pressure drop, BHP.
7. Actual flow rate, pressure drop, BHP.
8. Discharge pressure.
9. Suction pressure.
10. Total operating head pressure.

D. Air Cooled Condensers:
1. Identification/number.
2. Location.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Entering DB air temperature, design and actual.
7. Leaving DB air temperature, design and actual.
8. Number of compressors.

E. Cooling Coils:

1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Entering air DB temperature, design and actual.
7. Entering air WB temperature, design and actual.
8. Leaving air DB temperature, design and actual.
9. Leaving air WB temperature, design and actual.
10. Water flow, design and actual.
11. Water pressure drop, design and actual.
12. Entering water temperature, design and actual.
13. Leaving water temperature, design and actual.
14. Saturated suction temperature, design and actual.
15. Air pressure drop, design and actual.

F. Heating Coils:
1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Water flow, design and actual.
7. Water pressure drop, design and actual.
8. Entering water temperature, design and actual.
9. Leaving water temperature, design and actual.
10. Entering air temperature, design and actual.
11. Leaving air temperature, design and actual.
12. Air pressure drop, design and actual.

G. Air Moving Equipment:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Arrangement/Class/Discharge.
6. Air flow, specified and actual.
7. Return air flow, specified and actual.
8. Outside air flow, specified and actual.
9. Total static pressure (total external), specified and actual.
10. Inlet pressure.
11. Discharge pressure.
12. Sheave Make/Size/Bore.
13. Number of Belts/Make/Size.

14. Fan RPM.

H. Return Air/Outside Air:
1. Identification/location.
2. Design air flow.
3. Actual air flow.
4. Design return air flow.
5. Actual return air flow.
6. Design outside air flow.
7. Actual outside air flow.
8. Return air temperature.
9. Outside air temperature.
10. Required mixed air temperature.
11. Actual mixed air temperature.
12. Design outside/return air ratio.
13. Actual outside/return air ratio.

I. Exhaust Fans:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Air flow, specified and actual.
6. Total static pressure (total external), specified and actual.
7. Inlet pressure.
8. Discharge pressure.
9. Sheave Make/Size/Bore.
10. Number of Belts/Make/Size.
11. Fan RPM.

J. Duct Traverses:
1. System zone/branch.
2. Duct size.
3. Area.
4. Design velocity.
5. Design air flow.
6. Test velocity.
7. Test air flow.
8. Duct static pressure.
9. Air temperature.
10. Air correction factor.

K. Duct Leak Tests:
1. Description of ductwork under test.
2. Duct design operating pressure.

3. Duct design test static pressure.
4. Duct capacity, air flow.
5. Maximum allowable leakage duct capacity times leak factor.
6. Test apparatus:
    a. Blower.
    b. Orifice, tube size.
    c. Orifice size.
    d. Calibrated.
7. Test static pressure.
8. Test orifice differential pressure.
9. Leakage.

L. Terminal Unit Data:
1. Manufacturer.
2. Type, constant, variable, single, dual duct.
3. Identification/number.
4. Location.
5. Model number.
6. Size.
7. Minimum static pressure.
8. Minimum design air flow.
9. Maximum design air flow.
10. Maximum actual air flow.
11. Inlet static pressure.

END OF SECTION

SECTION 23 0713 - DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Glass Fiber, Flexible.

B. Glass Fiber, Rigid

C. Polyisocyanurate, Rigid

D. Jackets.

E. Duct insulation.

F. Insulation jackets.

1.2 RELATED REQUIREMENTS

A. Section 23 0553 - Identification for HVAC Piping and Equipment.

B. Section 23 3100 - HVAC Ducts and Casings

1.3 REFERENCE STANDARDS

A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2014.

B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric); 2014.

C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2017.

D. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.

E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014.

F. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2016.

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.

H. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2016.

I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Revised 2009).

J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.7 FIELD CONDITIONS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER, FLEXIBLE

A. Manufacturer:
   1. Johns Manville; _____: www.jm.com/#sle.
   2. Owens Corning Corporation; _____: www.ocbuildingspec.com/#sle.

B. Insulation: ASTM C553; flexible, noncombustible blanket.
   1. K value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
   2. Minimum Density of 1.0 PCF.

C. Vapor Barrier Jacket:
   1. 0.0032 inch vinyl.
   2. Moisture Vapor Permeability: 1.3 perm inch, when tested in accordance with ASTM E96/E96M.

3. Secure with pressure sensitive tape.

2.3 POLYISOCYANURATE, RIGID

A. Insulation consists of a pre-manufactured panel system consisting of four (4) piece interlocking panels.

B. The interlocking panels shall be constructed of Dow Thermax polyisocyanurate insulation, ASTM D-1622, normal 2 pcf.
   1. Water vapor transmission as permeance less than 0.03, per ASTM E-96;
   2. Water absorption less than 0.3% (24 Hours), per ASTM C-209.
   3. Flexural strenght more than 40 psi, per ASTM C-203.

C. Operating temperature range of -100 deg. F to +250 deg. F.

D. Insulation shall be clad with 0.032" thick embossed aluminum and sealed with vapor barrier compound. All joints shall interlock to ensure a thermal seal with no pass through seams.

E. Panels shall be secured with #10 self-tapping stainless screws with weather seal washers.

F. Manufacturers:
   1. P.T.M. Manufacturing, LLC Model Techna-Duc.
   2. Fab-Rite Exterior Duct Cladding System
   3. Substitutions: See Section 01 6000 - Product Requirements.

2.4 GLASS FIBER, RIGID

A. Manufacturer:
   1. Johns Manville; _____: www.jm.com/#sle.
   2. Owens Corning Corp: www.owenscorning.com.

B. Insulation: ASTM C612; rigid, noncombustible blanket.
   1. K Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
   2. Maximum Service Temperature: 450 degrees F.
   3. Maximum Water Vapor Absorption: 5.0 percent.
   4. Maximum Density: 8.0 lb/cu ft.

C. Vapor Barrier Jacket:
   1. 0.0032 inch vinyl.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.

2.5 JACKETS

A. Aluminum Jacket: ASTM B209 (ASTM B209M).
   1. Thickness: 0.016 inch sheet.
   2. Finish: Smooth.
   3. Joining: Longitudinal slip joints and 2 inch laps.
   4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.

5. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that ducts have been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.
   1. For rigid polyisocyanurate, installation shall only be completed by manufacturer licensed contractors.

B. Insulated ducts conveying air below ambient temperature:
   1. Provide insulation with vapor barrier jackets.
   2. Finish with tape and vapor barrier jacket.
   3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
   4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

C. Insulated ducts conveying air above ambient temperature:
   1. Provide with or without standard vapor barrier jacket.
   2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

D. Exterior Applications: Provide insulation with vapor barrier jacket. Cover with embossed aluminum.

E. External Duct Insulation Application:
   1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
   2. Secure insulation without vapor barrier with staples, tape, or wires.
   3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
   4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
   5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

3.3 SCHEDULES

A. All supply and return air ducts and plenums shall be insulated with a minimum of R-6 insulation when located in unconditioned spaces and a minimum of R-8 insulation when located outside the building. When located within a building assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation.
   1. Exceptions
      a. When located within equipment

b. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).

B. All exposed exterior duct to be insulated with rigid polyisocyanurate with cladding

C. All ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the International Mechanical Code.

END OF SECTION

SECTION 23 0719 - HVAC PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Flexible removable and reusable blanket insulation.

C. Jackets and accessories.

D. Engineered wall outlet seals and refrigerant piping insulation protection.

1.2 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 23 2300 - Refrigerant Piping: Placement of inserts.

1.3 REFERENCE STANDARDS

A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2014.

B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric); 2014.

C. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2016.

D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.

E. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2016.

F. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015.

G. ASTM G153 - Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials; 2013.

H. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.7 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 EPDM FLEXIBLE ELASTOMERIC CELLULAR INSULATION

A. Manufacturer:
   1. Armacell LLC; AP Armaflex: www.armacell.us/#sle.
   2. K-Flex USA LLC; K-Flex Titan: www.kflexusa.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
   1. Minimum Service Temperature: Minus 40 degrees F.
   2. Maximum Normal Service Temperature: 220 degrees F.
   3. Maximum "Upset Condition" Service Temperature: 250 degrees F for 10hr duration without degredation.
   4. Connection: Waterproof vapor barrier adhesive.

2.3 JACKETS

A. PVC Plastic.
   1. Manufacturers:
      a. Johns Manville Corporation; _____: www.jm.com/#sle.
      b. Substitutions: See Section 01 6000 - Product Requirements.
   2. Jacket: One piece molded type fitting covers and sheet material, off-white color.
      a. Minimum Service Temperature: 0 degrees F.
      b. Maximum Service Temperature: 150 degrees F.

c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
d. Thickness: 10 mil.
e. Connections: Brush on welding adhesive.

B. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
1. Lagging Adhesive: Compatible with insulation.

C. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
1. Thickness: 0.016 inch sheet.
2. Finish: Embossed.
3. Joining: Longitudinal slip joints and 2 inch laps.
4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

2.4 ENGINEERED WALL OUTLET SEALS AND REFRIGERANT PIPING INSULATION PROTECTION

A. Manufacturers:
1. Airex Manufacturing, Inc; ____: www.airexmfg.com/#sle.
2. Substitutions: See Section 01 6000 - Product Requirements.

B. Basis of Design: Airex Manufacturing, Inc; www.airexmfg.com/#sle.
1. Pipe Penetration Wall Seal: Airex Titan Outlet.
2. Refrigeration Pipe Insulation Protection System: Airex E-Flex Guard.
3. Pipe Penetration Wall Seal and Insulation Protection System: Airex Pro-System Kit.

C. Pipe Penetration Wall Seal: Seals HVAC piping wall penetrations with compression gasket wall mounted rigid plastic outlet cover.
1. Outlet Cover Color: Gray.

D. Pipe strut / hanger insulation
1. Hydra-Zorb "Klo-Shure" Series 7, 8, or 9 strut mounts
2. Hydra-Zorb TRH Hanger system
3. Substitutions: See Section 01600 - Product Requirements

E. Insulation Protection System: Refrigerant piping insulation PVC protective cover.
1. PVC Insulation Cover Color: Black with full-length velcro fastener.
2. Weatherization and Ultraviolet Exposure Protection: Comply with ASTM G153.
3. Water/Vapor Permeability: Comply with ASTM E96/E96M.
4. Anti-Fungal and Anti-Microbial Resistance: Comply with ASTM G21.
5. Flame Spread and Smoke Development Rating of 24/450: Comply with ASTM E84 or UL 723.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Exposed Piping: Locate insulation and cover seams in least visible locations.

C. Insulated pipes conveying fluids below ambient temperature; insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

D. Glass fiber insulated pipes conveying fluids below ambient temperature:
   1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
   2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.

E. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

F. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

G. Glass fiber insulated pipes conveying fluids above ambient temperature.
   1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
   2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

H. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 8400.

I. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.

J. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with PVC (with UV protection) jacket with seams located on bottom side of horizontal piping.

3.3 SCHEDULE

A. VRV/VRF Piping
   1. High Pressure Vapor Line up to <1" diameter: 1.5" thick EPDM Flexible Elastomeric Cellular
   2. Low Pressure Vapor Line up to <1" diameter: 1.0" thick EPDM Flexible Elastomeric Cellular
   3. Liquid Line up to <1" diameter: 1.0" thick EPDM Flexible Elastomeric Cellular

B. Condensate Drains from Cooling Coils: 1/2" EPDM Flexible Elastomeric Celluar Insulation

END OF SECTION

SECTION 23 0800 - HVAC SYSTEMS BASIC COMMISSIONING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. Ensure that all systems are operating in a manner consistent with the Contract Documents.

B. Execute all Basic Commissioning responsibilities assigned and include the cost of Basic Commissioning in the Contract price.
   1. Basic Commissioning of Systems does not need to be performed by a separate / specialty Commissioning Agent.

C. HVAC systems to be commissioned include the following:
   1. Air Handling Units
   2. Fans
   3. Piping Systems
   4. Ductwork Systems
   5. Fire, Fire/Smoke and Volume Dampers
   6. Roof Top Packaged DX Units
   7. Split Systems
   8. Terminal Units
   9. Unit Heaters
   10. Building Automation System

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.4 SUBMITTALS

A. Contractor shall prepare Prefunctional Checklists and Functional Performance Test (FPT) procedures and execute and document results. All Prefunctional Checklists and tests must be documented using

specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Owner for review and approval.

B. Contractor shall provide Owner with documentation required for Basic Commissioning Work. At minimum, documentation shall include: Detailed Start-up procedures, full sequences of operation, Operating and Maintenance data, performance data, Functional Performance Test Procedures, control drawings, and details of Owner-contracted tests.

C. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

D. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:
   1. Shop drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and A/E via the Contractor.
   2. Incorporate manufacturer's Start-up procedures with Prefunctional checklists.
   3. Draft Test, Adjust and Balance (TAB) Reports: Review and provide comments to Owner.
   4. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.
   5. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Owner may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.
   6. Final TAB Reports: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's.
   7. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 TEST EQUIPMENT

A. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

PART 3 EXECUTION

3.1 PREPARATION

A. Construction Phase:
   1. Provide manufacturer's data sheets and shop drawing submittals of equipment.
   2. Provide additional requested documentation to the Contractor, prior to O&M manual submittals, for development of Prefunctional Checklist and Functional Performance Tests procedures.
      a. Typically, this will include detailed manufacturer's installation and Start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified.
      b. In addition, the installation, Start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Contractor.
      c. This information and data request may be made prior to normal submittals.
   3. Develop the Commissioning Plan using manufacturer's Start-up procedures and the Prefunctional Checklists. Submit manufacturer's detailed Start-up procedures and the Commissioning Plan and procedures and other requested equipment documentation to Owner for review.
   4. During the Start-up and initial checkout process, execute and document related portions of the Prefunctional Checklists for all commissioned equipment.
   5. Perform and clearly document all completed Prefunctional Checklists and Start-up procedures. Provide a copy to the Owner prior to the Functional Performance Test.
   6. Address current A/E and Owner punch list items before Functional Performance Tests. Air and water test, adjust and balance shall be completed with discrepancies and problems remedied before Functional Performance Tests of the respective air or water related systems are executed.
   7. Provide skilled technicians to execute starting of equipment and to assist in execution of Functional Performance Tests. Ensure that they are available and present during the agreed-upon schedules and for a sufficient duration to complete the necessary tests, adjustments, and problem solving.
   8. Correct deficiencies (differences between specified and observed performance) as interpreted by the Owner's Project Manager and A/E and retest the system and equipment.
   9. Compile all Commissioning records and documentation to be included in a Commissioning and Closeout Manual.
   10. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to actual conditions.
   11. During construction, maintain Record Drawings and Specifications of all Contract Documents and Contractor-generated coordination Drawings. Update after completion of Commissioning activities (include deferred tests). The Record Drawings and Specifications shall be delivered to the Owner both in electronic format as required by the Owner.
   12. Provide training of the Owner's operating personnel as specified.
   13. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. Warranty Phase:
   1. Execute seasonal or deferred tests, witnessed by the Owner, according to the Specifications.

a. Complete deferred tests as part of this Contract during the Warranty Period. Schedule this activity with Owner. Perform tests and document and correct deficiencies. Owner may observe the tests and review and approve test documentation and deficiency corrections.
b. If any check or test cannot be completed prior to Substantial Completion due to the building structure, required occupancy condition, or other condition, execution of such test may be delayed to later in the Warranty Period, upon approval of the Owner. Contractor shall reschedule and conduct these unforeseen deferred tests in the same manner as deferred tests.

2. Correct deficiencies and make necessary adjustments to O&M manuals, Commissioning documentation, and Record Drawings for applicable issues identified in any seasonal testing.

3.2 TESTING

A. Prefunctional Checklists and Start-up:
1. Follow the Start-up and initial checkout procedures listed in this Section and in Division 01. Start-up and complete systems and sub-systems so they are fully functional, meeting the requirements of the Contract Documents.
2. Prefunctional Checklists shall be complete prior to commencement of a Functional Performance test.

B. Functional Performance Tests:
1. Functional Performance Tests are conducted after system Start-up and checkout is satisfactorily completed. Air balancing and water balancing shall be completed before Functional Performance Tests.

C. Coordination Between Testing Parties:
1. Factory Start-ups: Factory Start-ups are specified for certain equipment. Factory Start-ups generally are Start-up related activities that will be reviewed and checked prior to Functional Performance Tests. All costs associated with factory Start-ups shall be included with the contract price unless otherwise noted. Notify the Commissioning Team of the factory Start-up schedule and coordinate these factory Start-ups with witnessing parties. The Commissioning Team members may witness these Start-ups at their discretion.
2. Independent Testing Agencies: For systems that specify testing by an independent testing agency, the cost of the test shall be included in the Contract price unless otherwise noted. Testing performed by independent agencies may cover aspects required in the Prefunctional Checklists, Start-ups, and Functional Performance Tests. Coordinate with the independent testing agency so that Owner and/or A/E can witness the test to ensure that applicable aspects of the test meet requirements.

3.3 TRAINING

A. Owner to be Trained in operation of all HVAC systems controls

END OF SECTION

SECTION 23 0813 - HVAC SYSTEMS PREFUNCTIONAL TESTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. Contractor shall oversee the Commissioning activities with the Contractor's Subcontractors and the Architect/Engineer (A/E).

B. Contractor shall completely install, thoroughly inspect, Start-up, test, adjust and integrate air and water balance by Owner's TAB firm on systems and equipment. All activities shall be documented on specific, procedural forms developed for that purpose. Contractor shall notify A/E and Owner in writing that systems are complete and ready for verification and Functional Performance Tests.

C. Completed Prefunctional Checklists for all pieces of equipment shall be submitted to the Owner prior to Functional Performance Tests.

D. Responsibilities of the various parties involved in the Commissioning process are defined in Section 20 08 00.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.4 SUBMITTALS

A. Prefunctional Checklists, Prefunctional Tests, and Start-up documents are the normal procedure of ensuring that the mechanical, plumbing, and fire protection system components are properly installed.

B. The Subcontractor in cooperation with the A/E and Contractor shall develop Prefunctional Checklists and Prefunctional Tests during the Construction Phase.

C. Completeness of Prefunctional Checklists: This Section summarizes the minimum standard for systems and equipment checkout. A record of testing and acknowledgement that a procedure has been completed and that it checks out acceptably must be included in the Prefunctional Checklists. The

Prefunctional Checklist shall identify in columnar format each device, location, test method, control sequence of operation reference, device code reported, and other data as appropriate.

D. Equipment Data Documentation: Provide completed, as-installed, specific product nameplate data, product numbers, serial numbers, etc. to fully define the asset for Owner's use in maintenance management and asset tracking. This data may be incorporated within the Equipment Matrix as described in Division 01 as a spreadsheet format or electronic database. In addition to specific manufacturer's name and specific product identifiers such as model number, serial numbers, date of manufacture, etc, the following information shall be included with the equipment data documentation:
   1. Capacity data: Where applicable, use equipment schedules on the Drawings as a guideline for fields to be used.
   2. Location identifier field for each of the three dimensions (Floor Level, X axis, and Y axis) using the Drawing column grids as the basis for location.

E. Submit the equipment data documentation with the draft Prefunctional Checklists to the Owner for approval. A/E and Owner will review the Prefunctional Checklists and request any additional information required to meet the Commissioning Plan criteria.

F. Written Certification: The Contractor shall certify that the installation, Start-up, Prefunctional Checklist, and initial operation of the system or component is in accordance with the Contract Documents, Commissioning Plan, and manufacturer's requirements, and that the system is ready for Functional Performance Tests. Any outstanding items or non-conformance shall be clearly indicated and highlighted on the Prefunctional Checklist and an action item shall have been initiated. Refer to Division 01 for specific details on non-conformance issues relating to Prefunctional Checklists.

G. Refer to Section 23 08 00 for additional documentation requirements.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. The Prefunctional Checklist procedures described in this Section provide minimum guidelines for development of Prefunctional Checklists; Start-up procedures, and Prefunctional Tests. Contractor shall prepare the Prefunctional Checklists using these procedures and that of the manufacturers and/or applicable codes and standards.

C. The Prefunctional Checklist form shall acknowledge that installation and Start-up procedures were successfully adhered to and completely performed and shall document relevant parameters (panel and equipment connections, measured values, ground faults, trip settings, etc.). When indicated as performing a checkout on multiple items or multiple procedure items, Prefunctional Checklist forms shall itemize each individual item.

PART 3 EXECUTION

3.1 PREFUNCTIONAL CHECKLIST PROCEDURES

A. Valves:
   1. Operate all manual and automatic valves through their full stoke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
   2. Verify that actuators are properly installed with adequate clearance.
   3. For automatic, pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable.

B. Meters and Gauges:
   1. Adjust faces of meters and gauges to proper angle for best visibility.
   2. Clean windows of meters and gauges, including factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gauges that require temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure that threads are clean and that connection can be easily made.
   3. Meters and gauges requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

C. Mechanical Identification:
   1. Verify that all valve tags, piping, duct, and equipment labeling corresponds with the Drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
   2. Adjusting: Relocate any mechanical identification device which has become visually blocked by Work of this Division or other Divisions.
   3. Cleaning: Clean the face of identification devices and glass frames of valve charts.

D. Mechanical Insulation:
   1. Examine all systems and equipment specified to be insulated.
   2. Patch and repair all insulation that has been damaged after installation.
   3. Ensure the integrity of the vapor barrier around all cold surfaces.

E. Piping:
   1. The following applies to all installed piping systems including underground Site utilities. Responsibility for preparation of the Prefunctional Checklist and testing of the piping systems generally lies with the installing Subcontractor.
      a. Inspect all piping for proper installation, adequate support with appropriate vibration isolation where applicable, and adequate isolation valves for required service.
      b. Flush and treat all piping as appropriate to the application and clean all strainers.
      c. Ensure that adequate drainage is provided at low points and venting is provided at high points. Ensure that air is thoroughly removed from the system as applicable.
      d. Ensure that all piping is adequately supported and anchored to allow expansion. As applicable, bump across the line pumps and inspect for excessive pipe movement.

e. Pressure and/or leak test all applicable systems in accordance with requirements in the applicable Specification Sections. Record pressure testing results and certification that piping meets the Specification and submit with the Prefunctional Checklist.
f. Sterilize applicable piping systems as specified in the individual Specification Sections and as required by regulatory authorities. Record the results of sterilization and all parameters during this process and certify that the piping meets the Specification. Include results with Prefunctional Checklist.
g. Submit test reports that document testing results and certification of results with the Prefunctional Checklist.
h. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation. Document setting and actual trip points of all such controls.
i. Set and adjust fill, pressure, or level controls to the required setting.
j. Compare installation with mark-up Record Drawings to ensure the drawing accuracy.

F. AC Motors:
1. The following applies to all AC motors serving equipment.
a. Verify proper alignment, installation, and rotation.
b. Measure the insulation resistance, phase balance, and resistance to ground. These measurements will generally be the responsibility of the mechanical Subcontractor who is connecting the motor. The motor manufacturer will be responsible to correct any deficiencies. When electrical Subcontractor wires to a single point of a packaged device that is shipped with multiple motors, electrical Subcontractor shall check all motors in the package.
c. Verify that properly sized overloads are in place.
d. Measure voltage available to all phases at the time of initial connection and after the motor has been placed in operation under load measure amps and RPM.
e. Record all motor nameplate data.

G. Variable Frequency Drives:
1. General: Provide the services of a factory-authorized service representative to inspect unit installation, provide Start-up service, and demonstrate and train Owner's personnel. Contractor shall also provide the services of an independent harmonic testing agency as specified.
2. Start-up Checks: Perform the following checks before Start-up and as specified in manufacturer's Start-up instructions:
a. Check unit for shipping damage.
3. Perform a point-to-point continuity test for all field-installed wiring interconnections. Verify terminations of field-installed wiring.
4. Check for proper torque on connections.
5. Verify use of shielded cable where specified and check that shields have been terminated properly.
6. Verify grounding.
7. Check motor nameplate against drive input rating.
8. Manually rotate motor shaft to ensure free rotation.
9. Check that motor leads are not grounded.
10. Verify that factory test documentation is on file at the Project Site.
a. Starting procedures: Follow the manufacturer’s printed procedures with the following as a minimum:

1) Ensure device and system that the drive is serving, is configured to withstand the device operation specified as follows.
2) Verify, test and document safety circuits are active. Tag the safety circuit termination at the VFD and safety device with the trip value.
3) Set all parameters required and verify all parameters have been programmed consistently for all VFDs on the project. Coordinate with the BAS relative to the interfaces (hard wired or software) and failure restart, status interfaces, acceleration rates, feedback, alarm states etc.
4) Adjust the minimum voltage adjustment to enable starting but not to draw excessive power at start.
5) Adjust the Volts/Hz adjustment to the proper setting.
6) Adjust the accel and decel rates to the specified times.
7) Adjust current limiting to coordinate with the overcorrect device and protect the motor.
8) Set the maximum and minimum speed points.
9) Manually ramp fan speed from minimum to maximum and check for excessive noise and vibration.
10) Identify any critical speeds to avoid and set these in the drive.
11) With the independent harmonic testing agency, check for acceptable voltage and current distortion on the power system. Record the input and output voltages and currents showing the harmonic content as a percentage of the base frequency.
12) Measure and record overall efficiency at 50 percent, 75 percent, and 100 percent.
13) Record the motor terminal voltage.
14) Check operation prior to, during, and after a power outage to ensure required sequences and system restart.

H. Air Handling Units:
1. Manufacturer's Field Inspection or Custom Units: Arrange and pay for a factory-authorized service representative to inspect the field assembly of components and installation of custom air-handling units including piping, ductwork, and electrical connections.
2. Ensure that all O&M data for all components is provided and available at the Project Site.
3. Ensure that all access doors are provided and that they swing against pressure.
4. Check that all required service receptacles and light fixtures are installed and operating.
5. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Ensure that volatile irritants are contained and kept out of occupied spaces.
6. Vacuum clean the fan wheel, fan cabinet, and entering air face of coils.
7. Adjust and lubricate dampers and linkages for proper damper operation.
8. For field fabricated units, ensure the components are properly connected within acceptable tolerances.
9. Check that all sound attenuating devices are clean and properly installed.
10. Verify temperature sensing elements are secured properly with correct support devices as recommended by manufacturer.
11. Verify any high static cut out switches are properly installed with copper tubing, calibrated, tagged with trip set point, and wired.
12. Verify low temperature detection switches are hard wired interlocked to turn off fan and close OA damper.

13. Seal all penetrations air tight and ensure access doors seat tightly. Pressure tests the units to verify that they meet specified leakage.
14. Verify that the unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.
15. Ensure vibration isolation integrity is maintained throughout the air handling unit installation and the connections to it.
16. Refer to AC Motors in this Section.
17. Refer to Fans in this Section.
18. 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 belts, and install belt guards.
19. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
20. Comb coil fins.
21. Inspect coil piping connections and ensure that they are per the Contract Documents. Validate that all thermometers, pressure gauges, test ports, and balancing device connections are provided, accessible, and not plugged.
22. Install clean filters. Provide new filters at completion of Functional Performance Tests.
23. Ensure that condensate drains properly and that the trap is adequate.
24. Stroke all valves and dampers to ensure free and full travel.
25. Pressure test units as required in the air handling unit Specification.
26. Refer to Division 25, BAS Commissioning, for procedures on starting controls related to air handling units.

I. Fans - General Across Systems:
1. Manufacturer's Field Inspection: Arrange and pay for a factory-authorized service representative to inspect the field assembly of components and installation of fans including ductwork, and electrical connections.
2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Ensure that volatile irritants are contained and kept out of occupied spaces.
3. Vacuum clean the fan wheel, fan cabinet, and entering air face of coils.
4. Adjust and lubricate dampers and linkages for proper damper operation.
5. Verify that the unit is secure on mountings and supporting devices and that connections for ductwork and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.
6. Ensure that vibration isolation integrity is maintained with the fan installation and connections to the fan.
7. Refer to AC Motors in this Section.
8. Properly align and tension all belts. Record tensioning parameters in the Prefunctional Checklists.
9. 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 belts, and install belt guards.
10. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
11. Stroke all dampers to ensure free and full travel.
12. Refer to Division 25, BAS Commissioning, for procedures on starting controls related to fans.

J. Energy Recovery Wheels:
   1. Manufacturer's Start-up: Arrange and pay for a factory-authorized service representative to inspect the field assembly of components and installation of wheel, drive, controls, and electrical connections.
   2. Start-up Checks: Perform the following checks before Start-up and as specified in manufacturer's Start-up instructions.
      a. Check for damage to the wheel and that media and ensure media is evenly/thoroughly impregnated.
      b. Ensure that the wheel rotates freely.
      c. Ensure that all drive components are correctly installed, aligned, and lubricated.
      d. Ensure that air seals are tight and properly installed and that purge angles are set per the manufacturer's recommendations.
      e. Meet and coordinate with the BAS Provider to review the application for proper control of the wheel and interface of hardware.
      f. Verify that all controls are in place and that they are properly interfaced.
      g. Energize circuits:
         1) Check belt installation, tension, and alignment.
         2) Check for proper rotation in all modes of operation.
         3) Start and run the wheel through complete sequence of operations.
         4) Measure and record the sensible and latent recovery efficiency.
         5) Measure and record air pressure drop.
         6) Estimate purge volume.
         7) Check all interfaces to the BAS.
         8) Adjust operating controls.
         9) Provide services of an independent testing agency to test the cross contamination. Document all procedures and results.

K. Air Cleaning:
   1. Inspect installation and check for air leakage of unfiltered air while system is operating.
   2. Check access for filter installation.
   3. Check that filter efficiencies are per the Specifications.
   4. Validate that airflow is adequately even across the face.
   5. Provide new filters as required throughout construction and provide new filters at the completion of functional testing.

L. Metal Ductwork:
   1. Inspect all ductwork for damage and dents and correct any deficiencies.
   2. Check ductwork system to ensure that all required dampers, vanes, access doors, testing ports, and other appurtenances are required per the Contract Documents.
   3. Check all penetrations through building elements and ensure tightness and integrity of fire ratings.
   4. Leakage Tests: After each ductwork system that is constructed for ductwork pressure classification over 3 inches is completed, test for ductwork leakage in accordance with Section 23 31 00.

5. Clean ductwork internally of dust and debris, unit by unit as it is installed. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
6. Strip protective paper from stainless steel ductwork surfaces and repair finish wherever the finish has been damaged.
7. Temporary Closure: At ends of ductwork which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering that will prevent entrance of dust and debris until final ductwork connections are to be completed.
8. Check pressure class of ductwork against fan dead head to verify adequacy.

M. Ductwork Accessories:
1. Inspect and operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.
2. Develop a checkout sheet for all fire dampers. Physically inspect and operate every fire damper.
3. Install fusible links in fire dampers and adjust for proper action.
4. Label access doors in accordance with Contract Documents.
5. Fire Damper Testing: Coordinate with the local authority. For every fire damper, remove the fusible link and verify that the damper operates freely and closes tightly. Reinstall the fusible link.
6. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

N. Building Automation System:
1. Inspect installation for conformance to manufacturer’s requirements.
2. Verify controls for seasonal isolation and for modulation.
3. Verify discharge high limit controls are installed and functioning. Record limit setpoint and operating parameters.

3.2 ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

END OF SECTION

SECTION 23 0816 - HVAC SYSTEMS FUNCTIONAL PERFORMANCE TESTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. This Section expands on and defines responsibilities of the Contractor in regards to Functional Performance Tests (FPT's) of the Commissioning process.

B. Contractor shall oversee the Commissioning activities with the Contractor's Subcontractors and the Architect/Engineer (A/E).

C. Completed FPT Forms for all pieces of equipment and systems shall be submitted to the Owner prior to Substantial Completion.

D. Refer to Attachments A and B at the end of this Section for example forms that indicate level of documentation required for the Commissioning process.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.4 SUBMITTALS

A. Maintain and use an action item tracking system, "Action Item List," that indicates as a minimum, required information, identified deficiencies, work required, etc.). Each item shall be tracked with the initiator, the parties responsible, due date, the date of closure, and a description of the resolution. Each item shall be categorized for sorting and tracking and for documentation on applicable forms. Action Item List shall be distributed and documented using Microsoft Excel or a database format approved by Owner.

B. Disseminate this list as appropriate to keep all parties involved with the FPT informed.

C. Functional Performance Test procedure forms must include the following:
   1. System and equipment or component name(s).

2. Equipment location and identification number as identified in the Equipment Matrix described in Division 01.
3. Unique test identification number and reference to unique Prefunctional Checklist and Start-up Documentation Identification Numbers for the equipment.
4. Date and time of test.
5. Project name.
6. Participating parties.
7. Specific sequence of operation or other specified parameters, including performance data being verified.
8. Instructions for setting up a Functional Performance Test.
9. Specific script-type, step-by-step procedures to perform a Functional Performance Test, in a clear, sequential and repeatable format that is customized for the system being tested.
10. A Yes/No checkbox (or data entry box as appropriate) for clearly indicating whether or not proper performance of each part of a Functional Performance Test was achieved with space for actual readings.
11. Section for comments.
12. Signatures and date block for participants and Owner approvals.

D. Refer to Division 01 and 20 08 00 for additional documentation requirements.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

PART 3 EXECUTION

3.1 PREPARATION

A. The objective of FPT's is to demonstrate that each system operates according to the Contract Documents through all specified modes of operation.

B. Contractor shall operate each system through all modes of operation (occupied, unoccupied, warm-up, cool-down, etc.) where there is a specified system response. Verification of each sequence in the sequences of operation is required.

C. All equipment, components and devices applicable to the FPT must be started and this Start-up must be documented. This documentation includes completion of the Prefunctional Checklists, pressure testing of equipment, duct, pipe, etc., flushing/cleaning of applicable systems, completed labeling and identification, completed insulation of applicable systems, etc. Refer to Section 23 08 13 for additional Prefunctional Checklist and Start-up requirements.

D. Unless specifically agreed to by the Commissioning Team, all support systems shall be complete prior to FPT.
1. The electrical system serving it is completed and tested.

2. The hydronic systems serving it have been balanced and FPT completed.
3. Balancing has been accomplished on the air and water sides.
4. The building automation system (BAS) has been started and calibrated.

E. Commissioning Team members shall assist in development and review of the optimal sequence of testing.

3.2 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

3.3 FUNCTIONAL PERFORMANCE TEST PROCEDURES

A. The purpose of a Functional Performance Test is to verify and document compliance with the stated criteria of acceptance. Contractor shall develop specific script-type test procedures and associated test forms to verify and document proper operation of each piece of equipment and system.

B. Contractor shall operate, or cause to be operated, each system, device, or equipment item, both intermittently and continuously, for a duration period as indicated in the Specification Section(s) for such item and/or in accordance with the manufacturer's written recommendations, the Contract Documents, and the Commissioning Plan.

C. Contractor shall operate each component device and each building system to the full extent of its capability, from minimum to maximum, and under automatic control and manual control.

D. Contractor and manufacturer's representatives shall supervise and coordinate adjustments and balancing of all devices and systems for proper operation prior to requesting the Functional Performance Test(s).

E. Where final balancing of a system is to be performed by Owner or Owner's consultants, such as final air balancing, Contractor shall provide all services indicated in the applicable Technical Sections and under this Section, including the following prior to Owner's final balancing:
1. Operational verification of all component devices and the total system, including automatic controls when applicable. Operational verification includes verification that all motors, fans, dampers, and other operable devices are performing in compliance with Specifications throughout their operable range and that all devices are controlled as described in the specified sequence of operation.
2. All tabulated data, motor amperage readings, valve tag verifications, and other data required by Technical Specifications.

F. Where final balancing of a system or particular components of a system are not specifically indicated to be performed by Owner or Owner's consultants, Contractor shall provide final balancing and adjustments for operation within specified tolerances prior to Functional Performance Test of such system.

G. Sampling: Some types of identical equipment (such as terminal devices) will be tested using a sampling strategy. The sample percentage is indicated below. [Insert equipment list and sampling percentage.]

H. Failure Limit on Sample Tests: With the sampling percentages is listed a failure limit. This limit indicates the maximum percentage of the tested devices that may have any test that fails before an entirely new sample must be tested. When the maximum number of failures is reached, testing on that sample will be terminated and re-testing will be scheduled.
   1. Where sample tests involve multiple systems (i.e.: Checking strainers on different hydronic systems) the maximum failure limit will apply per system.

I. Deferred Tests: Contractor shall schedule with the Owner and complete Deferred Tests as part of this Contract during the Warranty Period. Testing procedures shall be repeated and/or conducted as necessary during appropriate seasons. Deferred or "Opposite season" tests will be required where scheduling prohibits thorough testing in all modes of operation. Air Handler and central heating system testing for heating related modes of operation and control loops shall be tested during outside air temperatures below 50 degrees F. Air handler and central cooling system testing for cooling related modes of operation and control loops shall be tested during outside air temperatures above 85 degrees F.

J. Provide and deliver the required submitted documentation convenient to testing area. Validate that all required documentation has been submitted to the Owner and is per the Contract Document requirements.

K. Review the Start-up documentation at the start of FPT's. Ensure that any items indicated as outstanding in the Prefunctional Checklist is entered as an Action Item and enter one if it is not. The Prefunctional Checklists and Start-up tests/measurements shall be spot checked at the beginning of FPT's to ensure accuracy. Complete a test that indicates Contractor has reviewed the Prefunctional Checklists and finds the Prefunctional Checklists acceptable and notes any outstanding items.

L. Check for and as applicable direct the Subcontractor to demonstrate that access is sufficient to perform required maintenance.

M. Validate that all prerequisite work is complete and confirm this validation via a test record for documentation.

N. Specifically check labeling and ensure conformance to the Contract Documents.

O. Analyze trends of the system operating parameters to evaluate normal system functionality. The trending requirements are specified in the BAS Commissioning Specification, however all systems must be trended and reviewed prior to and as part of functional performance trending. Subcontractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the Contractor. Analyzed trends shall be organized and/or grouped in a manner that clearly demonstrates the individual components of a piece of equipment is under total control and display this information together. The trend group data shall be labeled with the system name or the purpose of the trend group or data and submitted in a Microsoft Excel spreadsheet.

P. Check proof indication, alarming on failure and restart/acknowledgement as applicable.

Q. Observe operating conditions encountered at the start of the FPT. Contractor shall examine for normal functionality and record parameters as a test.

R. All dynamic systems powered by electricity shall be tested to simulate a power outage to ensure proper sequencing. Those on emergency power or uninterruptible power shall be tested on all sources. This test shall generally be coordinated with electrical power systems testing addressed in the Contract Documents.
   1. Emergency power tests for mechanical systems will be conducted in concert with the testing of the emergency power systems. Testing Contractor shall be available for the power outage test to test their systems under a power outage. This is in addition to the requirement specified by system.

S. Inspect the installation and compare it to the Contract Documents. Record the inspection as a test.

T. Capacities and adjusted and balanced conditions as applicable will generally be checked.

U. Verify all sequence modes and sequences of operation. Contractor must initiate all modes and may not refer to or rely on a Prefunctional Test done by the building automation system. Some examples of generic modes that apply to most systems include:
   1. Off mode.
   2. Failed mode: Proof, safeties, power outage etc. See below for crash testing.
   3. Start sequence in various modes.
   4. Stop sequences in various modes.

V. All adjusted, balanced, controlled systems shall be assessed to determine the optimal setting for the system as applicable. The optimal settings should be determined to establish reliable, efficient, safe and stable operation. The Contractor is responsible for placing systems in optimal condition for occupancy and not simply relying on initial design estimated settings.

W. Dynamic Graphics: The graphic for all components, systems, and areas sampled and required to be represented by a graphic shall be checked for adequacy and accuracy. Furthermore, when setpoints are required to be adjustable, verify that they can be adjusted directly from the graphic screen.

X. All interfaces between two systems or equipment of different manufacturers must be checked for accuracy and functionality.

Y. Contractor shall to the extent possible, load the heating and cooling systems during initial FPT's to check the capacity of the building central systems and initially optimize system settings. This will typically be done using the preheat system to false load the cooling system. This test will incorporate varying the load to check central systems response.

Z. "Crash Testing": Contractor shall analyze systems to identify possible conditions where functionality may be compromised. Contractor shall design non-destructive tests that will demonstrate either the automated response to the conditions or so that team can identify the best method for responding or fixing the condition. All tests and their findings shall be documented in a Microsoft Excel spreadsheet.

3.4 PARTICIPATION

A. Required participating parties are indicated with the individual tests. Typically, multiple parties are required for any given test, yet participation for any given party is only required for the respective portion of the test for which the party is responsible. In many cases, the maximum required time in hours is

indicated in parenthesis for any given test. The time is typically per unit system unless indicated otherwise. If no time is indicated, participation is required throughout the entire test.

B. Frequently, on multiple samples where a given party does not directly conduct the test, the participation of that party will only be required for an initial quantity of systems/equipment. It is required that the parties be available on-site throughout the testing of any given system for which they are required participants. Therefore time for which they are not directly involved can be spent performing other work (typically addressing identified punch list items or failed test).

C. No party involved with the Project is prohibited from participation in or witnessing of any tests. Any Subcontractor may elect to witness all tests on their systems even if their involvement is not directly required.

D. Coordinate effectively with the individual Subcontractors throughout the development and execution of FPT's and maximize Subcontractors' involvement.

3.5 ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

END OF SECTION

SECTION 23 0911 - SIEMENS BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes control equipment and installation for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-furnished controls.

B. See "Sequences of Operation" for requirements that relate to this Section.

1.2 ABBREVIATIONS

A. AAC: Advanced Application Controller

B. AHU: Air Handling Unit.

C. ALN: Automation Level Network

D. ASC: Application Specific Controller

E. ASHRAE: American Society of Heating Refrigerating and Air-Conditioning Engineers

F. BAS: Building Automation System

G. BC: Building Controller

H. BIBB: BACnet Interoperability Building Blocks

I. BIM: Building Information Modeling

J. BMS: Building Management System.

K. CFM: Cubic Feet per Minute.

L. DCIM: Data Center Infrastructure Management

M. DCV: Demand Controlled Ventilation

N. DDC: Direct digital controls

O. EIA: Electronics Industries Alliance

P. EMI: Electro-Magnetic Interference

Q. EP: Electric-to-Pneumatic

R. EPMS: Electrical Power Monitoring System

S. FAS: Fire Alarm System.

T. FLN: Floor Level Network

U. FCU: Fan Coil Unit

V. HMI: Human Machine Interface

W. HVAC: Heating, Ventilating and Air Conditioning.

X. IEEE: Institute of Electrical and Electronic Engineers

Y. I/O: Input/Output

Z. IP: Internet Protocol

AA. IT: Information Technology

AB. LAN: Local area network.

AC. LCD: Liquid Crystal Display

AD. LED: Light Emitting Diode

AE. MER: Mechanical Equipment Room.

AF. MLN: Management Level Network

AG. MS/TP: Master-slave/token-passing.

AH. NEMA: National Electric Manufacturers' Association

AI. NFPA: National Fire Protection Association

AJ. OEM: Operator Equipment Manufacturer

AK. PC: Personal Computer

AL. PICS: Protocol Implementation Conformance Statement

AM. PID: Proportional Integral Derivative.

AN. POT: Portable Operators Terminal.

AO. RAM: Random Access Memory

AP. RFI: Radio Frequency Interference

AQ. RTD: Resistance Temperature Device

AR. SNMP: Simple Network Management Protocol

AS. TAB: Testing and Balancing

AT. TCP: Transfer Control Protocol

AU. UDP: User Datagram Protocol

AV. UL: Underwriters Laboratories

AW. UPS: Uninterruptable Power Supply

AX. VAV: Variable Air Volume

AY. VFD: Variable Frequency Drive.

AZ. WAN: Wide Area Network.

1.3 DEFINITIONS

A. BACnet: An industry standard data communication protocol for Building Automation and Control Networks. Refer to the latest version of AHSRAE standard 135.

B. Scope Terminology
   1. Provide = Furnish equipment, engineer, program and install
   2. Furnish = Furnish equipment, engineer and program
   3. Mount = securely fasten or pipe
   4. Install = mount and wire
   5. Wire = wire only

1.4 WORK INCLUDED

A. The BAS Contractor shall provide a complete and operational system that will perform the sequences of operation as described herein.

B. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system controllers, logic controllers, and all input/output devices. Items of work included are as follows:
   1. Provide a submittal that meets the requirements below for approval.
   2. Coordinate installation schedule with the mechanical contractor and general contractor.
   3. Provide installation of all panels and devices unless otherwise stated.
   4. Provide power for panels and control devices unless otherwise stated.
   5. Provide all low voltage control wiring for the DDC system.
   6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
   7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
   8. Provide testing, demonstration and training as specified below.

C. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.

1.5 SUBMITTALS

A. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submittals for the following items separately upon request:
   1. Valve schedule and product data
   2. Damper schedule and product data
   3. Mounting and wiring diagrams for factory-installed control components
   4. Thermostat locations

B. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:
   1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   2. Wiring Diagrams: Power, signal, and control wiring. Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.
   3. Details of control panel faces, including sizes, controls, instruments, and labeling.
   4. Schedule of dampers and actuators including size, leakage, and flow characteristics. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.
   5. Schedule of valves including leakage and flow characteristics.
   6. Written description of the Sequence of Operations.
   7. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.
   8. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
   9. Starter and variable frequency drive wiring details of all automatically controlled motors.
   10. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.
   11. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
   12. Submit BACnet Protocol Implementation Conformance Statements (PICS) for all direct digital controllers, software and other system components that will communicate on the BAS utilizing BACnet.

C. Submit a description of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

D. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.

E. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.

F. After the BAS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

G. Operation and Maintenance Data: In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
   1. Product data with installation details, maintenance instructions and lists of spare parts for each type of control device.
   2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
   3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.
   4. Calibration records and list of set points.

1.6 PROJECT RECORD DOCUMENTS

A. Project Record Documents: Submit three (3) copies of record (as-built) documents upon completion of installation. Submittal shall consist of:
   1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD compatible files in electronic format and as 11 x 17 inch prints.
   2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements in the Control System Demonstration and Acceptance section of this specification.
   3. Operation and Maintenance (O & M) Manual.
      a. As-built versions of the submittal product data.
      b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
      c. Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
      d. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

f. Documentation of all programs created using custom programming language, including setpoints, tuning parameters, and object database.
g. Graphic files, programs, and database on electronic media.
h. List of recommended spare parts with part numbers and suppliers.
i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
j. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
k. Licenses, guarantees, and warranty documents for equipment and systems.

B. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
1. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.
2. Description of manual override operation of all control points in system.
3. BMS system manufacturers complete operating manuals.

C. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:
1. Complete as-built installation drawings for each building system.
2. Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.
3. Photographs and/or drawings showing installation details and locations of equipment.
4. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.
5. Parts list with manufacturer's catalog numbers and ordering information.
6. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.
7. Manufacturer's operation, set-up, maintenance and catalog literature for each piece of equipment.
8. Maintenance and repair instructions.
9. Recommended spare parts.

D. Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum include the following:
1. Complete programming manuals, and reference guides.
2. Details of any custom software packages and compilers supplied with system.
3. Information and access required for independent programming of system.

1.7 QUALITY ASSURANCE

A. Codes
1. Perform all wiring in accordance with Division 26, NEC, local codes and Owner’s requirements.
2. 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.
3. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

4. Comply with ASHRAE 135-2010 BACnet: A Data Communication Protocol for Building Automation and Control Networks.
5. Comply with ASHRAE 90.1-undefined2007undefinedundefined2010undefined[object Object]2013undefined Energy Standard for Buildings Except Low-Rise Residential Buildings.
6. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems,
    a. Provide written approvals and certifications after installation has been completed.
    b. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
    c. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

B. Qualifications
1. Installing contractor shall be in the business of installing and servicing DDC controls for mechanical systems, temperature and ventilation control, environmental control, lighting control, access and security, life safety and energy management as their primary business.
2. Installer Qualifications: An experienced installer who is the authorized representative of the automatic control system manufacturer for both installation and maintenance of controls required for this Project.
3. 3Engineering, drafting, programming, and graphics generation shall be performed by the local branch engineers and technicians directly employed by the Building Automation System Contractor.
4. Supervision, checkout and commissioning of the system shall be by the local branch engineers and technicians directly employed by the Building Automation System Contractor. They shall perform commissioning and complete testing of the BAS system.

C. The BAS contractor shall maintain a service organization consisting of factory trained service personnel and provide a list of ten (10) projects, similar in size and scope to this project, completed within the last five years.

D. Final determination of compliance with these specifications shall rest solely with the Engineers and Owner who will require proof of prior satisfactory performance.

E. For any BAS system and equipment submitted for approval, the BAS contractor shall state what, if any, specific points of system operation differ from these specifications.

F. All portions of the system must be designed, furnished, installed, commissioned and serviced by manufacturer approved, factory trained employees.

G. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to building controllers, advanced application controllers, application specific, personal operator workstations and portable operator's

terminals, to be connected and directly communicate with any new BAS system equipment without bridges, routers or protocol converters.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Deliver, store, protect, and handle products to site under provisions of the contract Documents. Coordinate all site delivers with Construction project Manager.

C. Protect products from construction operations, dust, and debris, by storing materials inside, protected from weather in a conditioned space.

1.9 COORDINATION

A. Coordinate IP drops, network connections, user interfaces, firewall, etc with Owner's IT representative.

B. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.

C. Coordinate equipment with Division 28 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate power for control units and operator workstation with electrical contractor.

E. Coordinate equipment with provider of starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.

F. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.

G. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

H. Products Furnished but Not Installed Under This Section
   1. Hydronic and Refrigerant Piping accessories:
      a. Control Valves
      b. Temperature Sensor Wells and Sockets
      c. Pressure Sensor Wells and Sockets
      d. Flow Switches
      e. Flow Meters
      f. Differential Pressure Transmitters
      g. Sheet metal accessories
         1) Dampers
         2) Airflow Stations
         3) Terminal Unit Controls

I. Products Installed but Not Furnished Under This Section

1. Refrigeration Equipment:
    a. Refrigerant Leak Detection System
    b. Proof of flow pressure switches
    c. Rooftop Air Handling Equipment:
        1) Thermostats
        2) Duct Static Pressure Sensors

J. Products Integrated To but Not Furnished or Installed Under This Section

1.10 WARRANTY

A. Provide warranty per Division 20 Section “General Mechanical Requirements” and as supplemented in this section.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of 12 months from completion of system demonstration.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

D. During normal building occupied hours, failure of items that are critical for system operation shall be provided within 4 hours of notification from the Owner’s Representative.

E. This warranty shall apply equally to both hardware and software.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

A. The Building Automation System (BAS) contractor shall furnish and install a networked system of HVAC controls. The contractor shall incorporate direct digital control (DDC) for central plant equipment, building ventilation equipment, supplemental heating and cooling equipment, and terminal units.

B. Provide networking to new DDC equipment using industry accepted communication standards. System shall utilize BACnet communication according to ANSI/ASHRAE standard 135-2010 for interoperability with smart equipment, for the main IP communication trunk to the BAS Server and for peer-to-peer communication between DDC panels and devices. The system shall not be limited to only standard protocols, but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

C. Provide standalone controls where called for on the drawings or sequences.

D. The BAS shall be the Siemens APOGEE system as manufactured by Siemens Building Technologies.

2.2 BUILDING AUTOMATION SYSTEM NETWORK

A. All networked control products provided for this project shall be comprised of an industry standard open protocol internetwork. Communication involving control components (i.e. all types of controllers and operator interfaces) shall conform to ASHRAE 135-2010 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.
   1. Software applications, features, and functionality, including administrative configurations, shall not be separated into several network control engines working together.

C. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.

D. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

E. Any break in Ethernet communication between the server and standard client workstations on the Primary Network shall result in a notification at each workstation.

F. The network architecture shall consist of three levels of networks:
   1. The Management Level Network (MLN) shall utilize BACnet/IP over Ethernet along with other standardized protocol, such as web services, html, JAVA, SOAP, XML, etc., to transmit data to non-BAS software applications and databases. The BAS Server and Operator Workstations shall reside on this level of the network architecture.
   2. The Automation Level Network (ALN) shall utilize BACnet/IP over Ethernet. It shall connect BACnet Building Controllers to the BAS Server and Operator Workstations. Controllers for central plant equipment and large infrastructure air handlers shall reside on the ALN backbone BACnet/IP network. The building's Ethernet LAN shall be utilized for the ALN backbone and all ALN devices shall be connected to the building's LAN. Coordinate IP drops with Owner.
   3. The Floor Level Network shall utilize BACnet/IP over Ethernet or BACnet MS/TP over RS-485 to connect all of the DDC-controlled terminal heating and cooling equipment on a floor or in a system that are controlled with BACnet Advanced Application Controllers or BACnet Application Specific Controllers. FLN devices are networked to a router that connects to the Automaton Level Network backbone.

G. The primary backbone network between the building level controllers, BAS Server and Operator Workstations shall be based upon BACnet/IP. Ethernet Network switches shall be strategically placed through the building to cover several floors or several mechanical rooms that are within 300 ft wiring-feet of each other

H. Use fiber optic cabling for all Ethernet runs longer than 300 ft

I. Provide a router for each RS-485 subnetwork to connect them to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet. Routers shall

be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

J. The Building Level Controllers shall be able to support subnetwork protocols that may be needed depending on the type of equipment or application. Subnetworks shall be limited to :
   1. BACnet MS/TP
   2. Apogee FLN
   3. Modbus

K. BACnet MSTP Setup rules
   1. Addressing for the MSTP devices shall start at 00 and continue sequentially for the number of devices on the subnetwork.
   2. No gaps shall be allowed in the addresses.
   3. Set the MaxMaster property to the highest address of the connected device.
   4. MaxMaster property shall be adjusted when devices are added to the subnetwork.

L. Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for the internetwork.

M. Controllers and software shall be BTL listed at the time of installation.

N. The system shall meet 8peer-to-peer communication services such that the values in any one BACnet Building Controller or BACnet Advanced Application Controller can be read or changed from all other controllers without the need for intermediary devices. The software shall provide transparent transfer of all data, control programs, schedules, trends, and alarms from any one controller through the internetwork to any other controller, regardless of subnetwork routers.

O. Systems that use variations of BACnet using Point-to-Point (PTP) between controllers, gateways, bridges or networks that are not peer-to-peer are not allowed.

P. **Remote Communications: Provide a TCP/IP compatible communication port for connection to the Owner's network for remote communications. Provide coordination with the Owner for addressing and router configuration on both ends of the remote network.**
   1. **All setpoints, alarms, graphics shall be able to be seen, accepted and modified on the Owner's Central Siemens Control System**

Q. The system shall be installed with a 10% spare capacity on each subnetwork for the addition of future controllers.

R. On each floor, wing or major mechanical room provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

S. Distributed Control Requirements:
   1. The loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.

2. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
4. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarms to multiple operator workstations without dependence upon a central or intermediate processing device.
5. Operators shall have the ability to make database changes at the central system server while operator workstations are on-line without disrupting other system operations.
6. The DDC control panel shall be mounted in the same mechanical room as the equipment being controlled, or an adjacent utility room.
7. Multiple systems can be programmed on the same controller as long as they are in the same room. Systems on separate floors shall have separate controllers.
8. VAV boxes subnetworks shall be connected to the AHU controller that feeds those boxes. If multiple subnetworks are needed, then the VAV shall be grouped into subnetworks in an orderly method, such as per floor, per wing, etc.
9. Remote sensors shall be wired to the control panel of the equipment it is controlling, not across the network.
10. Signals to remote motor control centers shall be hard wired to the control panel, not across the network.
11. Terminal units shall each have their own controller. Only exceptions are:
    a. Groups of reheat coils
    b. Groups of exhaust fans
    c. Groups of chilled beams serving same zone or several adjacent zones

2.3 WEB BASED OPERATOR INTERFACE SOFTWARE

A. Provide a Web-based graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet (TCP/IP). The Web-based graphical interface shall use HTML-based pages to send and receive data directly from a network of BAS Field Panels to a Web browser.

B. The web server shall support browser access via Microsoft Internet Explorer 6.0 (or later), Firefox, or any browser that supports the compatible plug-in.
    1. Cookies are allowed for compatibility
    2. Microsoft Java Applet (JVM) is allowed for compatibility
    3. Adobe Flash Player shall be allowed for compatibility

C. The web server shall support access via handheld, web enabled devices through apps. The apps shall be available for download from public sites, such as Apple iTunes or Google Play.

D. The Web server shall allow monitor and control of data in any field panels networked together on the same automation level TCP/IP Ethernet network.

1. The Web server must provide a common alarm display that shows alarms in all field panels on the network.
2. The Web server must be able to provide common graphics that simultaneously display the current value and status for points residing in multiple field panels.
3. The Web server must be able to display daily mode schedules for points from multiple field panels simultaneously.

E. Access to the Web interface shall be username and password protected. A user's rights and privileges to database objects within the BAS shall be configurable on a per-user basis. An option shall exist to only allow users "read" access to BAS objects via the Web browser. Operator sessions shall be configurable for "auto-logoff" after a designated period of user inactivity.
   1. A graphic selector list shall allow or limit the graphic displays that a user account has access to.
   2. The embedded Web server shall support an unlimited number of user accounts. A minimum of five concurrent user sessions shall be available for simultaneous operator access to the Web server's pages.
   3. The embedded Web server shall be compatible with and allow coexistence within standard IT security policies and tools (e.g., Firewall protection).

F. The embedded Web server shall provide the following functionality to users via Web browser, based on their access and privilege rights:
   1. Point Navigation - Provide a screen that allows users to see all of the points that are active in the system. The points shall include hardwired, software, schedules, trends, alarms and network setup.
      a. The point navigation shall display the point name, descriptor, command priority, alarm status, and current value.
      b. The user shall be able to run and print a pre-configured point log report through a web interface client that shows the point name, descriptor, command priority, alarm status, and current value.
      c. The interface and report shall allow selection filter such that the operator can select or deselect the types of point that are visible.
      d. Alarm Display -displays current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge active alarms, erase resolved alarms, and directly link to the Point Commanding feature.
         1) The alarm display must provide a filter that displays all alarms whether acknowledged or not.
         2) The alarm display must provide a filter that displays only alarms that have not yet been acknowledged.
         3) The alarm display must provide a persistent indication whenever there is one or more unacknowledged alarm in any connected field panel.
      e. Point details - users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
      f. Point Commanding - users will be able to override and command points they have access to via the Web browser interface.
      g. Scheduling - allows operators, depending on their current user privileges, to override schedules selected by date, and to modify the properties of a selected schedule.

1) The scheduler display must be able to represent facility mode schedules in a graphical format.

h. Trend Data Report - allows users to run and print a pre-configured trend data report for historical data reporting, including a representation of the alarm status of the each point for each Trend sample. The report shall allow selection of individual points or wildcard selection of points.
   1) Trend data shall be exportable to a data file, such as .csv or other comparable.

i. Network navigation - Provide a screen that allows users to navigate to the panels and terminal units via the network architecture.

G. Graphic Displays - The BAS contractor shall provide a graphical display for each system that is controlled.
   1. Display of system graphics shall be available for viewing over the Web browser. Graphic displays will automatically refresh with the latest change of values. Users shall have the ability to command and override points directly from the graphic display as determined by their user accounts rights. The Graphic Display shall accommodate a minimum of 10 customized graphics.
   2. The Graphic Display shall accommodate the terminal unit graphics related to the Application Specific Controllers tied in to the Field Panels within the system.

H. The web server shall be able to send SMTP text messages to notify users of alarm status. The owners shall provide a mail server and a connection port. SSL shall not be required.

I. The operator shall be able to add modify and delete controller database program, including points, schedules, alarms, and trends.
   1. The operator shall be able to edit the custom program in the field panel that executes the sequences of operations, control loops and logic for the systems controlled.
   2. The operator shall be able to add terminal unit controllers that reside on field panel subnetworks.

J. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the Web access feature. Coordinate networking, security, and user access to the Web Server interface with the Owner's IT representative.

2.4 WEB BASED CONTROLLER SOFTWARE FOR CONFIGURATION, PROGRAMMING AND OPERATORS

A. The purpose of this specification is to allow the Owner/Operator to have the same controller programming capabilities as the Controls Contractor Technician without additional software, tools, or licenses.
   1. The controller programming shall be accessible to any user via a Web Services application over an IP or Internet connection through port 80.

B. The following types of controllers shall have this feature:
   1. All BACnet BC level controllers
   2. Network Engine Controllers
   3. Controllers on equipment or sequences customized for this job

C. Manufacturer:
   1. Siemens Launch Pad™ (compatible with PXC controllers)
   2. Controllers from other manufacturers shall meet the capabilities of this specification

D. The controller shall come with the software built-in and delivered with the controller as part of the controller purchase. It shall not require a separate software license to enable the software capability.
   1. The software shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

E. The software application shall be accessible from a PC using Web Services, but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.

F. Access to the controller software shall be username and password protected. User shall be authenticated by the controller.

G. The embedded Web Services shall provide the following functionality to users, based on their access and privilege rights:
   1. Point Navigation - Provide a screen that allows users to see all of the points that are active in the system. The points shall include hardwired, software, schedules, trends, alarms and network setup.
      a. The point navigation shall display the point name, descriptor, command priority, alarm status, and current value.
      b. The user shall be able to run and print a pre-configured point log report through a web interface client that shows the point name, descriptor, command priority, alarm status, and current value.
      c. The interface and report shall allow selection filter such that the operator can select or deselect the types of point that are visible.
      d. Alarm Display -displays current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge active alarms, erase resolved alarms, and directly link to the Point Commanding feature.
         1) The alarm display must provide a filter that displays all alarms whether acknowledged or not.
         2) The alarm display must provide a filter that displays only alarms that have not yet been acknowledged.
         3) The alarm display must provide a persistent indication whenever there is one or more unacknowledged alarm in any connected field panel.
      e. Point details - users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
      f. Point Commanding - users will be able to override and command points they have access to via the Web browser interface.
      g. Scheduling - allows operators, depending on their current user privileges, to override schedules selected by date, and to modify the properties of a selected schedule.
         1) The scheduler display must be able to represent facility mode schedules in a graphical format.
      h. Trend Data Report - allows users to run and print a pre-configured trend data report for historical data reporting, including a representation of the alarm status of the each point for

each Trend sample. The report shall allow selection of individual points or wildcard selection of points.

1) Trend data shall be exportable to a data file, such as .csv or other comparable.

i. Network navigation - Provide a screen that allows users to navigate to the panels and terminal units via the network architecture.

H. The web server shall be able to send SMTP text messages to notify users of alarm status. The owners shall provide a mail server and a connection port. SSL shall not be required.

I. The operator shall be able to add modify and delete controller database program, including points, schedules, alarms, and trends.
   1. The operator shall be able to edit the custom program in the field panel that executes the sequences of operations, control loops and logic for the systems controlled.
   2. The operator shall be able to add terminal unit controllers that reside on field panel subnetworks.

J. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the Web access feature.

K. Coordinate with the Owner/Operator's IT representatives to setup and allow access to controllers via IP connections and Web Services through port 80.
   1. It shall be the responsibility of the Owner/IT to setup and maintain security for user access to the private networks.
   2. Coordinate IP addressing scheme.

2.5 DIRECT DIGITAL CONTROLLER SOFTWARE

A. Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.

B. The software program shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

C. The software shall be provided with an interactive HELP function to assist operators with syntax, abbreviations, commands and saving programs.

D. Point naming and communication format:
   1. All points, panels, and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
   2. All digital points shall have a consistent, user-defined, two-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).
   3. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.

E. System Security
   1. User access shall be secured using individual security passwords and user names.
   2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
   3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
   4. User Log On/Log Off attempts shall be recorded.
   5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
   6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the DDC controller software.

F. User Defined Control Applications: The applications software shall program DDC routines to meet the sequences of operations.
   1. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
   2. The Building Controllers shall have the ability to perform the following pre tested control algorithms:
      a. Two position with differential control and time delays
      b. Floating control
      c. Proportional control
      d. Proportional plus integral control
      e. Proportional, integral, plus derivative control
      f. Automatic tuning of control loops
      g. Model-free adaptive control
      h. Start Stop Time Optimization
      i. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
      j. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

G. Peer-to-peer access to other DDC controllers
   1. It shall be possible to use any actual or virtual point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
   2. Any process shall be able to issue commands to points in any and all other controllers in the system.

3. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of an advanced annunciation feature, such as:
    a. Generate a report
    b. Annunciate an alarm
    c. Issue a text message or email

H. Alarm Management
1. Alarm management shall be provided within the controller software to monitor and direct alarm information to operator devices.
2. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
3. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
4. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
5. Binary Alarms. Each binary alarm object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
6. Analog Alarms. Each analog alarm object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
7. All alarm shall include the point's user-defined language description and the time and date of occurrence.
8. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print reports, be logged in the event log, generate custom messages, and display graphics.
9. The user shall be able to add a 200-character alarm message to each alarm point to more fully describe the alarm condition or direct operator response. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.
10. Operator-selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.
11. An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.

I. Scheduling:
1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
2. Schedules shall reside in the building controller and shall not rely on external processing or network.
3. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
5. The operator shall be able to define the following information:
    a. Time, day
    b. Commands such as on, off, auto, etc.

c. Time delays between successive commands.
d. There shall be provisions for manual overriding of each schedule by an authorized operator.
e. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
    1) Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
    2) Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

J. Peak Demand Limiting (PDL):
1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
2. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

K. Temperature-compensated duty cycling
1. User defined conditions shall be able to initiate a Duty Cycle Control Program.
2. The Duty Cycle Control Program (DCCP) shall be configured to periodically stop and start loads according to various patterns.
3. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

L. Automatic Daylight Savings Time Switchover. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

M. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

N. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

O. Control Loop Algorithm

1. Provide a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be accessible from the operator workstation.

P. Adaptive Loop Tuning
   1. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.
   2. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
   3. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
      a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
      b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

Q. Logic programming: Provide a software routine that can build ladder logic to control using many conditional statements.
   1. The logic programming syntax shall be able to combine ladder logic with other software features, such as combining status, scheduling, PDL and alarm conditions into one conditional decision.
   2. Logic programming shall be able to reference conditions in any other controller in the system.

R. Staggered Start:
   1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable in an application and shall not require written scripts or ladder logic.
   2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

S. Totalization Features:
   1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
   2. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

T. Data Collection:
1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.
5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
6. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

2.6 BACNET BUILDING CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Siemens PX Modular and Compact Controllers (PXC).

C. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:
1. Data Sharing
   a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
   b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
   c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
   d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
   e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
   f. Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A,B)
   g. Scheduling
      1) Scheduling-Internal- Execute (SCHED-I-B)
      2) Scheduling-External- Execute (SCHED-E-B)
   h. Trending
      1) Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)
      2) Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
      3) Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)
      4) Trending-Automated Trend Retrieval- Execute (T-ATR-B)
   i. Network Management

1) Network Management-Connection Establishment- Initiate (NM-CE-A)

j. Alarming
   1) Alarm and Event-Notification- Initiate (AE-N-A)
   2) Alarm and Event-Notification Internal- Execute (AE-N-E-B)
   3) Alarm and Event-Notification External- Execute (AE-N-E-B)
   4) Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
   5) Alarm and Event -Alarm Summary- Execute (AE-ASUM-B)
   6) Alarm and Event -Enrollment Summary- Execute (AE-ESUM-A,B)
   7) Alarm and Event -Information- Initiate, Execute (AE-ESUM-A,B)

k. Device Management
   1) Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
   2) Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
   3) Device Management-Device Communication Control- Execute (DM-DCC-B)
   4) Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
   5) Device Management-Text Message- Initiate, Execute (DM-TM-A,B)
   6) Device Management-Time Synchronization- Execute (DM-TS-B)
   7) Device Management-Reinitialize Device- Execute (DM-RD-B)
   8) Device Management-Backup and Restore- Execute (DM-RD-B)
   9) Device Management-List Manipulation- Execute (DM-RD-B)
   10) Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

l. The Building Level Controller shall support the following Data Link Layers:
   1) BACnet IP Annex J
   2) BACnet IP Annex J Foreign Device
   3) MS/TP Master (Claus 9)

m. The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   1) Calendar - Creatable, Deletable
   2) Command - Creatable, Deletable
   3) Event Enrollment - Creatable, Deletable
   4) Notification Class - Creatable, Deletable
   5) Schedule - Creatable, Deletable

n. The Building Level Controller shall support transmitting and receiving segmented messages.

o. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

p. The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

D. This level of controller shall be used for the following types of systems:
   1. Chiller plant systems
   2. Heating plant systems
   3. Cooling Towers
   4. Pumping systems
   5. VAV air handlers
   6. Air handlers over 15,000 cfm

7. Systems with over 24 input/output points
8. Rooftop systems

E. Computing power and memory minimum:
1. A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.
2. Inputs shall be 16-bit minimum analog-to-digital resolution
3. Outputs shall be 10-bit minimum digital-to-analog resolution
4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.
5. Real time clock and battery
6. Data collection/ Data Trend module sized for 10,000 data samples.
7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

F. Onboard or Modular hardware and connections:
1. Primary Network communication module, if needed for primary network communications.
2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port

G. Input and Output Points Hardware
1. Input/output point modules as required including spare capacity.
2. Input/output point modules shall have removable terminal blocks.
3. Monitoring of the status of all hand-off-auto switches.
4. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
5. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
6. Graduated intensity LEDs or analog indication of value for each analog output.

H. Code compliance
1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

I. Accessories:
1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

J. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

K. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

L. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

M. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

N. Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.

O. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

P. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

R. Environment.
   1. Controller hardware shall be suitable for the anticipated ambient conditions.
   2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
   3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
   4. Controller hardware shall be optionally suitable for rooftop environments.

S. Immunity to power and noise.
   1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
    a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
    b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
    c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
    d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
    e. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:
        1) IEEE Standard 587 1980
        2) UL 864 Supply Line Transients
        3) Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.7 BACNET ADVANCED APPLICATION CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Unitary Equipment Controller (PXCxx-UCM).

C. The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004 or ANSI/ASHRAE 135-2008. Supported BIBBS shall include:
    1. Data Sharing
        a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
        b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
        c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
        d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
        e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
        f. Scheduling
            1) Scheduling-Internal- Execute (SCHED-I-B)
        g. Trending
            1) Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
            2) Trending-Automated Trend Retrieval- Execute (T-ATR-B)
        h. Network Management
            1) Network Management-Connection Establishment- Initiate (NM-CE-A)
        i. Alarming
            1) Alarm and Event-Notification Internal- Execute (AE-N-I-B)
            2) Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
            3) Alarm and Event -Enrollment Summary- Execute (AE-ESUM-B)
            4) Alarm and Event -Information- Execute (AE-INFO-B)
        j. Device Management

1) Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
2) Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
3) Device Management-Device Communication Control- Execute (DM-DCC-B)
4) Device Management-Time Synchronization- Execute (DM-TS-B)
5) Device Management-Reinitialize Device- Execute (DM-RD-B)
6) Device Management-Backup and Restore- Execute (DM-BR-B)
7) Device Management-List Manipulation- Execute (DM-LM-B)
8) Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

k. The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
1) Calendar - Creatable, Deletable
2) Command - Creatable, Deletable
3) Event Enrollment - Creatable, Deletable
4) Notification Class - Creatable, Deletable
5) Schedule - Creatable, Deletable

l. The Advanced Application Controller shall support transmitting and receiving segmented messages.

D. Communication:
1. BAS Network: The Advanced Application Controller shall support the following Data Link Layers:
a. MS/TP Master
b. Serial Communication: Temporary use of portable devices shall not interrupt the BAS communication, nor the normal operation of permanently connected printers or terminals.
1) Provide at least one EIA-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals.
2) A USB port shall alternatively be available to support local HMI tools connection.

E. Software
1. The software programs specified in this section shall be provided as an integral part of Advanced Application Controllers and shall not be dependent upon any higher level computer or another controller for execution.
2. Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to
a. scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides
b. automatic daylight savings time switch over
c. night setback control
d. economizer switch over using enthalpy, dry bulb or a combination
e. peak demand limiting,
f. temperature-compensated duty cycling
g. heating/cooling interlock
h. supply temperature reset
i. priority load shedding
j. power failure restart

k. The software shall have a routine for automatic tuning of control loops
l. System Security in the Field Panel
    1) User access shall be secured using individual security passwords and user names.
    2) Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
    3) The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
    4) Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.
m. User Defined Control Applications:
    1) Controllers shall be fully-programmable. Controllers shall execute custom, job-specific sequences to automatically perform calculations and special control routines. Factory installed or pre-configured sequences shall only be allowed if they exactly match the sequence specified herein.
    2) Programs shall combine control logic, control loop algorithms, and energy management routines
    3) Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
    4) Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

F. Adaptive Loop Control.
1. Each AAC controller shall come standard with an Adaptive Control Loop Algorithm
    a. Tuning parameter shall automatically adjust for non-linear applications
    b. Model-Free Adaptive (MFA) algorithm
        1) The algorithm shall not require modeling of the non-linear system in order to maintain control at all points of the non-linear load.
        2) The controlled variable, setpoint, and weighting parameters shall be user-selectable.
    c. Output shall be analog or shall stage a series of outputs.
    d. Adaptive Control shall take the place of Proportional, Proportional + Integral, and PID type algorithms for non-linear applications. Adaptive Control routines shall :
        1) Improve response time
        2) Improve System efficiency
        3) Improve Stability
        4) Result in Consistent outputs
        5) Reduce cycling and repositioning
        6) Reduce wear and tear on actuators
    e. Adaptive control shall auto-adjust to compensate for
        1) mode changes
        2) load changes
        3) seasonal changes
        4) Heating and cooling changeover
        5) Heating or cooling capacity changes on the primary side
        6) Flow changes on the primary or secondary side

7) Airflow changes across coil
8) Flow across a heat exchanger

f. Adaptive control shall auto-adjust to compensate for
1) Non-linear coils and heat exchangers
2) Hot water and chilled water reset routines
3) Water flow reset routines
4) Duct Static reset routines

g. Auto-Tune PID loops are not acceptable substitutions.

h. If Adaptive Loop Control is not available, then the BAS contractor shall provide re-tuning of the control loops for coils and heat exchangers for each of the following conditions:
1) Low heating supply water, high heating supply water
2) Low load on steam coil, high load on steam coil
3) Chilled water coil, non dehumidification and condensing
4) Chilled water coil, low airflow, high airflow, economizer
5) Dual temperature systems tune for heating and cooling modes
6) Each of 4 seasons

G. This level of controller shall be used for the following types of systems:
1. Systems with custom sequences that meet all of the criteria below:
2. No primary pumping systems
3. Secondary Pumping systems that are remote from Central Plants
4. Air handlers up to 15,000 cfm
5. Systems up to 20 input/output points
6. Room control sequences that cannot be achieved with an application specific controller
7. BAS Network or Architecture or Sequences do not require the system to be on an IP network
8. No systems that require integration to meters, VFDs or other smart equipment
9. Integration to smart thermostats is allowed

H. Input/Outputs
1. Inputs shall be 16-bit minimum digital resolution
2. Outputs shall be 10-bit minimum digital resolution
3. The following I/O port types shall be available on the controller
a. Universal Input (software configurable):
1) Digital Input choices:
(a) Pulse Accumulator
(b) Contact Closure Sensing
(c) Dry Contact/Potential Free inputs only
(d) Digital Input (10 ms settling time)
(e) Counter inputs up to 20 Hz, minimum pulse duration 20 ms (open or closed)
(f) Analog Input Choices:
(1) 0-10 Vdc
(2) 4-20 mA
(3) 1K Ni RTD @ 32°F (Siemens, JCI, DIN Ni 1K)
(4) 1K Pt RTD (375 or 385 alpha) @ 32°F
(5) 10K NTC Type 2 or Type 3 Thermistor

(6) 100K NTC Type 2 Thermistor

2) Universal Input or Output (software configurable):
   (a) All of the above input types
   (b) Analog Output Types:
      (1) 0 to 10 Vdc @ 1 mA max
3) Super Universal Input or Output (software configurable):
   (a) All of the above input types
   (b) All of the above output types
   (c) Super digital output type:
      (1) 0 to 24 Vdc, 22 mA max. (for controlling pilot relay)
   (d) Super Analog Output Choices:
      (1) 0 to 20 mA @ 650 O max.

b. Provide software configurable I/O ports such that a programmer make a port either an input or an output

I. Each System Level Control Panel shall, at a minimum, be provided with:
1. Appropriate NEMA rated metal enclosure.
2. A 32-bit,multi-tasking, real-time 100 MHz digital control microprocessor with plug-in, enclosed processors.
3. Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
4. Real time clock and battery
5. Data collection/ Data Trend module sized for 10,000 data samples.
6. Power supplies as required for all associated modules, sensors, actuators, etc.
7. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
8. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
9. Each control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
10. Graduated intensity LEDs or analog indication of value for each analog output.

J. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for the operating system software and firmware.
1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Brownout protection and power recovery circuitry protect the controller board from power fluctuations.
3. Battery backup shall be provided to support the real-time clock for 10 years
4. The program and database information stored SDRAM memory shall be battery backed for a minimum of 30 days and up to 60 days. This eliminates the need for time consuming program and database re-entry in the event of an extended power failure.

K. Database Restore: Each AAC controller shall automatically save the latest programmed database. The controller shall be able to automatically restore a lost or corrupt database without involvement from the operator.

L. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

M. Each Control Panel shall support firmware upgrades without the need to replace hardware.

N. System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Control panels shall allow temporary use of portable operator interface devices without interrupting the normal communications.

O. Immunity to noise.
   1. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
   2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
      a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
      b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
      c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
      d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
      e. Isolation shall be provided at all Advanced Application Controller's AC input terminals to suppress induced voltage transients consistent with:
         1) IEEE Standard 587 1980
         2) Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

P. Agency Compliance
   1. UL UL916 PAZX (all models)
   2. UL916 PAZX7 (all models)
   3. FCC Compliance CFR47 Part 15, Subpart B, Class B

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be "future" on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2.8 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

B. Controllers in areas where moisture is a concern shall be mounted in NEMA 12 enclosures.

C. Controllers installed outdoors shall be mounted in NEMA 4X enclosures. Provide heaters where freezing temperatures are normally experienced.

D. Mount on walls at an approved location or provide a free standing rack.

E. Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

F. Provide power supplies for control voltage power.

G. Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

H. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

I. All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

J. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.

K. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

L. Provide a pocket to hold documentation.

2.9 SENSORS

A. General
   1. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.
   2. If a special tool is required to mount a device, provide that tool.

B. Terminal Unit Space Thermostats
   1. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
      a. Plain Space Temperature Sensors - Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
      b. The sensing element for the space temperature sensor shall be thermistor type providing the following.
         1) Element Accuracy: + /- 1.0°F
         2) Operating Range: 55 to 95°F
         3) Set Point Adjustment Range: 55 to 95°F

4) Calibration Adjustments: None required
5) Installation: Up to 100 ft. from controller
6) Auxiliary Communications Port: as required
7) Local LCD Temperature Display: as required
8) Setpoint Adjustment Dial as required
9) Occupancy Override Switch as required
10) Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

c. Digital Display temperature sensor specifications - Wired:
   1) As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
   2) The sensing element for the space temperature sensor must be IC-based and provide the following.
      (a) Digitally communicating with the Application Specific Controller.
      (b) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
      (c) IC Element Accuracy: +/- 0.9°F
      (d) Operating Range: 55 to 95°F
      (e) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
      (f) Display of temperature setpoint with numerical temperature values
      (g) Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
      (h) Calibration: Single point, field adjustable at the space sensor to +/- 5°F
      (i) Installation: Up to 100 ft. from controller
      (j) Auxiliary Communications Port: included
      (k) Local OLED Temperature Display: included
      (l) Display of Temperature to one decimal place
      (m) Temperature Setpoint Adjustment included
      (n) Occupancy Override Function included
   3) Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

d. Provide the following options as they are called for in the sequences or on the drawings:
   1) Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized

operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

2) Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

3) Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

C. Temperature Sensors

1. All temperature sensors shall meet the following specifications:
   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Vibration and corrosion resistant
   d. Space temperature sensors shall meet the following specifications:
      1) 10k ohm type 2 thermistors
   e. Insertion Elements in Ducts shall meet the following specifications:
      1) Single point 10k ohm thermistor
      2) Use where not affected by temperature stratification
      3) The sensor shall reach more that 1/3 the distance from the duct wall
      4) Junction box for wire splices
   f. Averaging Elements in Ducts shall meet the following specifications:
      1) 72 inches (183 cm) long
      2) Flexible
      3) Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
      4) Junction box for wire splices
   g. Insertion Elements for Liquids shall meet the following specifications:
      1) Platinum RTD with 4-20mA transmitter
      2) Threaded mounting with matching well
      3) Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4” diameter
      4) Brass well with insertion length of 6 inches for pipes up to 10” diameter
      5) Junction box for wire splices
   h. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
      1) Watertight enclosure, shielded from direct sunlight
      2) Circulation fan
      3) Watertight conduit fitting

D. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:
   1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
   2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
   3. Space Sensors with LCD display:
      a. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off
      b. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint

E. Humidity Sensors shall meet the following specifications:
   1. Bulk polymer sensor element
   2. Accuracy: 2 percent full range with linear output
   3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
   4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity

F. Air Static Pressure Transmitter shall meet the following specifications:
   1. Non-directional sensor with suitable range for expected input, and temperature compensated.
   2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   3. Output: 4 to 20 mA.
   4. Building Static-Pressure Range: 0 to 0.25 inches wg.
   5. Duct Static-Pressure Range: 0 to 5 inches wg.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

H. Equipment operation sensors as follows:
   1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
   2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
   3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
   4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

I. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel and 0 to 10 V dc, feedback signal.

J. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vapor proof type.

K. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and

the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.

L. Leak detectors: Provide spot leak detectors that can be secured to the floor or secured to a drain pan. The detection shall used a microchip controlled energized probes. The detector shall operate on 24Vor less. Provide a way to adjust the height of the leak probes. The SPDT contacts shall be inside a watertight enclosure.

2.10 ELECTRO-MECHANICAL THERMOSTATS

A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:
   1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.
   1. Bulb Length: Minimum 20 feet.
   2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

2.11 AUTOMATIC CONTROL VALVES

A. General:
   1. All automatic control valves shall be fully proportioning, un-less specified otherwise. The valves shall be quiet in opera-tion and fail-safe in either normally open or normally closed position in the event of control air failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load re-quirements. The valves shall be capable of operating in se-quence with other valves and/or dampers when required by the se-quence of operation. All control valves shall be sized by the control vendor and shall be guaranteed to accommodate the flow rates as scheduled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. Body pressure rating and connec-tion type construction shall conform to fitting and valve sched-ules. Control valve operators shall be sized to close against a differential pressure equal to the design pump heads plus 10 percent.
   2. Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.
   3. Unless otherwise specified, control valves 2 inches and smaller shall have cast iron or bronze bodies with screwed NPT connections.
   4. Valves between 2-1/2 inch and 4 inch shall have cast iron bodies with flanged connections.

5. All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating charac-teristics and accessories as described in herein. Coor-dinate with electrical contractor for power availability and point of connection.
6. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless noted otherwise in these documents.
7. All automatic control valves shall be installed by the mechanical trade.
8. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.
   c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.
   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

B. Characterized Ball Valves
   1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
   2. Body pressure rating and connec-tion type construction shall conform to fitting and valve sched-ules.
      a. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
      b. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
      c. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
      d. All automatic control valves shall be installed by the mechanical trade.
      e. The controls contractor shall provide wiring as follows:
         1) All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
         2) All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
         3) All wiring between safeties and the valve actuator shall be wired by the controls contractor.
         4) All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

C. Manufacturer
   1. Siemens 599 series valves bodies, SSD, SAX, SQV Actuators, Series 230, 231, 232, 233, 238, 239, 371, and 373 assemblies

D. Threaded Valves, line size ½" to 2"
   1. Controlled Media Specific Items

a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 230°F (110°C).
b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 230°F (110°C).
c. General Construction Materials/Applicable Standards
    1) Control valve bodies shall be constructed of forged brass according to ASTM B283 (C37700, CuZn39Pb2 or equivalent), and shall meet requirements of ANSI 250 and 600WOG pressure classes.
    2) Inlets and outlets shall be clearly marked on the valve bodies.
    3) Valve ball shall consist of nickel-plated brass, chrome-plated brass or stainless steel.
    4) End connections shall be NPT internally threaded according to ANSI B1.20.1.
    5) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
    6) The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A single glass filled PTFE V port insert shall provide both the ball seal and shall establish the flow coefficient of the valve. The V port insert shall be retained by the valve body itself, not requiring additional retaining components. Flow coefficient adapters requiring a retainer clip, or installed after final assembly of the valve or as inserts in the ball shall not be allowed.
    7) 2-way valves and the A-AB path on 3-way valves shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure. Bypass path (B-AB) on 3-way valves shall meet the requirements of ANSI Class III (0.1% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2.
    8) Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.
    9) Valve stem shall be made of brass or stainless steel.
    10) Valve shall have the ability to be manually operated in the event of a power failure.

E. Actuators - Electric
1. The valves shall be provided with an actuator by the same manufacturer, factory installed.
2. All actuators shall have visual position indication.
3. No external programming device shall be required.
4. Actuator shall be electric motor driving, microprocessor signal controlled.
5. Modulating valves shall be positive positioning, responding to a 0-10VDC, 2-10VDC or 4-20mA signal. Floating modulating signals are acceptable for modulation on terminal units and radiation units. There shall be a visual valve position indicator.
6. Power: All actuators shall be 24VAC power and less than 100VA draw. Power shall be via Class 2 wiring. Actuators requiring more than 100VA shall have a dedicated conduit for power wiring, not mixed with the signal wiring.

7. Fail Safe: Valves actuators shall position the valve in a fail-safe position when the power supply is disrupted or the signal goes to 0. Fail-safe according to the following guidelines unless otherwise stated in the sequence of operations
    a. Power fail safe shall be via spring loaded mechanical means
    b. Any AHU hot water exposed to ventilation air shall fail open
    c. AHU Chilled water coils exposed to ventilation air in possible freezing conditions shall be fail open
    d. AHU Chilled water coils that are drained in winter months or are in climate zones without freezing conditions shall be fail-in-place
    e. Terminal unit valves shall fail-in-place
    f. Fail in Safe valves on primary equipment such as chilled water systems, hot water systems and condenser water systems shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch.
    g. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
    h. Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10%, and still be rated for a Class IV leakage.
    i. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
    j. All automatic control valves installed in locations exposed to the elements shall be provided with weather resistant housings and heaters for climates that reach below freezing.
    k. Actuators shall be UL and CSA listed.

F. Hot Water / Condenser Water / Control Valves
    1. Single-seated.
    2. Fully proportioning with modulating plug or V-port inner valves.
    3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.
    4. Stainless steel stems and trim.
    5. Spring loaded Teflon packing
    6. Quiet in operation.
    7. Fail-safe in either normally open or normally closed position in the event of power failure.
    8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
    9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

G. Differential Pressure Control Valves :
    1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each closed loop water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

H. Steam Valves:
   1. Steam control valves shall be of linear flow characteristics for modulating service.
   2. Sizing Criteria:
      a. 15 psig or less; pressure drop 80% of inlet psig.
      b. 16 to 50 psig; pressure drop 50% of inlet psig.
      c. Over 50 psig; pressure drop as scheduled on plans.
      d. Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:
         1) Heating coils in air handlers: normally open.
         2) Steam to hot water heat exchanger: normally closed.
         3) Other applications: as required by sequences of operation.

2.12 ELECTRONIC ACTUATOR SPECIFICATION

A. ELECTRONIC VALVE ACTUATORS
   1. Actuator shall be fully modulating, floating (tri-state), two position, and/or spring return as indicated in the control sequences. Specified fail safe actuators shall require mechanical spring return.
   2. Modulating valves shall be positive positioning, responding to a 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
   3. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
   4. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
   5. Actuators shall be UL listed.

B. ELECTRONIC DAMPER ACTUATORS
   1. Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.
   2. Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.
   3. For power-failure/safety applications, a mechanical, spring return mechanism shall be used.
   4. Actuators with spring return mechanisms shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
   5. Proportional actuators shall accept a 2-10VDC, 4-20mA signal, or be of the 2 point floating type and provide a 2-10VDC actuator position feedback signal.
   6. All actuators shall have an external manual gear release (clutch) or manual crank to aid in installation and for allowing manual positioning when the actuator is not powered.
   7. All actuators shall have an external direction of rotation switch to aid in installation and to allow proper control response.
   8. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box.

9. Actuators shall be listed under Underwriters Laboratories Standard 873 and Canadian Standards Association. They must be manufactured under ISO 9001.

PART 3 EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate-or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others-the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others.

3.2 INSTALLATION

A. Provide all relays, switches, and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.

B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

D. Install equipment level and plumb.

E. Install control valves horizontally with the power unit up.

F. Unless otherwise noted, install wall mounted thermostats and humidistat 60" above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.

G. Install averaging elements in ducts and plenums in horizontal crossing or zigzag pattern.

H. Install outdoor sensors in perforated tube and sunshield.

I. Install damper motors on outside of duct in protected areas, not in locations exposed to outdoor temperatures.

J. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

K. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.

L. Furnish automatic dampers to mechanical contractor for installation.

3.3 GRAPHIC DISPLAY GENERATION

A. All software shall be capable of providing color graphics. All software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

B. Provide a main default screen showing the basic layout of the building. Each color graphic screen shall have transfer links to allow the building operator to transfer between system associated screens (both forward and backward), as well as a transfer link back to the main default screen.

C. Basic CAD floor plans with layers for walls, windows, low pressure ductwork only, supply diffusers and room numbers shall be provided for all CV, VAV, and FPVAV terminal units. Floor plans shall show the location of each space temperature sensor with a dashed line to the associated terminal unit. Display in real time the difference between the space temperature and the current setpoint.
   1. Display the
      a. cooling %,
      b. heating % (if applicable)
      c. current CFM of each terminal unit.
      d. Provide a transfer link for each terminal unit to allow the operator to access the flow graphic for each individual terminal unit. Use a different color to shade the background area for each part of a floor plan graphic served by a different air handling unit.

D. All control set points shall be easily adjustable from the system's color graphic screen by operators with the proper access level. Each controlled point on the BAS operator workstation color graphic screens shall have the set point indicated along with the actual controlled variable reading (preferred set point on top and actual reading on bottom). All points shall indicate the associated engineering unit. All analog outputs points shall indicate engineering units such as "%-open" or "%-closed" as required by the application. All normally-closed or normally-open points shall indicate the normal position (such as "N.C." or "N.O." next to the controlled device).

E. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS. Provide scaled floor plans indicating equipment location, service, and system data as required.

F. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

G. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

H. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

I. The windowing environment of the operator interface shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   1. Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   2. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

J. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers.

K. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

L. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

M. Provide an additional dynamic, graphic display pages as required by the operating staff to further assist in daily system operations.

N. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

O. Each graphic shall have a “BACK” button and a “HOME” or “MAIN” button located in the same location on all graphics.

P. The operator shall be able to clearly distinguish the difference between the following types of points on a graphic either by color, shape, icon or text label:
   1. Real-time sensor reading
   2. Setpoint
   3. Manually set vs. program set Setpoint
   4. Real-time output reading
   5. Manually Overridden or commanded output vs program set output
   6. Status feedback from a piece of equipment vs the output command

Q. Make appear links to additional information associated with the system on the graphic, such as:
   1. Controls as-built schematics and wiring diagrams
   2. As-built Sequence of Operation
   3. Mechanical drawings

4. Electrical drawings

R. Integration graphics shall be representative of personnel standing in front of equipment. The graphics for equipment specified in the Building Systems Integration paragraph shall be representative of the manufacturers' local display panel and each shall be completely operable from the computer workstation.

3.4 ELECTRICAL WIRING SCOPE

A. This contractor shall be responsible for power that is not shown on the electrical drawings, to controls furnished by this contractor. If power circuits are shown on the electrical drawings, this contractor shall continue the power run to the control device. If power circuits are not shown, this contractor shall coordinate with the electrical contractor to provide breakers at distribution panels for power to controls. This contractor is then responsible for power from the distribution panel.
   1. Coordinate panel locations. If enclosures for panels are shown on the electrical drawings, furnish the enclosures according to the electrician's installation schedule.

B. This contractor shall not be responsible for power to control panels and control devices that are furnished by others, unless it is part of the control interlock wiring.

C. Refer to Coordination section for what devices this contractor is responsible to mount and which are turned over to others to mount.

D. This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

E. Interlock wiring shall be run in separate conduits from BAS associated wiring.

F. Provide network wiring for equipment that is called to be integrated to the BAS.

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

B. Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

C. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

D. Install building wire and cable according to Division 26 Section "Conductors and Cables."

E. Installation shall meet the following requirements:
   1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway or conduit.
   3. Install concealed cable using plenum rated cable.
   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. All wiring in lab areas shall be in conduit.
8. All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.

F. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

G. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

H. Install conduit adjacent to machine to allow service and maintenance.

I. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

J. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

K. Ground equipment.

3.6 COMMUNICATION WIRING

A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

B. Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

E. Cable bundling:
1. RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.
2. RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.
3. RS485 cabling run between floors shall be in a communication only conduit.
4. RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.
5. Ethernet cabling shall be in a communication only conduit.

6. Ethernet and RS485 can be run together.
7. Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

F. RS485 Cabling
1. RS485 cabling shall be used for BACnet MS/TP networks.
2. RS485 shall use low capacitance, 20-24 gauge, twisted shielded pair.
3. The shields shall be tied together at each device.
4. The shield shall be grounded at one end only and capped at the other end.
5. Provide end of line (EOL) termination devices at each end of the RS485 network or subnetwork run, to match the impedance of the cable, 100 to 120ohm.

G. Ethernet Cabling
1. Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.
2. CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.
3. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
4. When the BAS Ethernet connects to an Owner's network switch, document the port number on the BAS As-builts.

H. Fiber-Optic Cabling
1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.
2. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.
3. All terminations shall to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

I. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

J. All runs of communication wiring shall be unspliced length when that length is commercially available.

K. All communication wiring shall be labeled to indicate origination and destination data.

L. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.7 IDENTIFICATION

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows: C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

C. Control Equipment and Device labeling:
   1. Labels and tags shall match the unique identifiers shown on the as-built drawings.
   2. All Enclosures shall be labeled to match the as-built drawing by either control panel name or the names of the DDC controllers inside.
   3. All sensors and actuators not in occupied areas shall be tagged.
   4. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
   5. Duct static pressure taps shall be tagged at the location of the pressure tap.
   6. Each device inside enclosures shall be tagged.
   7. Terminal equipment need only have a tag for the unique terminal number, not for each device. Match the unique number on:
      a. First, the design drawings, or
      b. Second, the control as-builts, or
      c. Third, the DDC addressing scheme
      d. Tags on the terminal units shall be displayed on the Operator Workstation Graphics.

D. Tags shall be mechanically printed on permanent adhesivebacked labeling strips, 12 point height minimum.

E. Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

F. Identification of Wires
   1. Tag each wire with a common identifier on each end of the wire, such as in the control panel and at the device termination.
   2. Tag each network wire with a common identifier on each end.
   3. Tag each 120V power source with the panel and breaker number it is fed by.

G. Identification of Conduits:
   1. Identify the low voltage conduit runs as BAS conduit, power feeds not included.
   2. Identify each electric box, junction box, utility box and wiring tray with a blue paint mark or blue permanent adhesive sticker.
   3. For conduit runs that run more than 8 ft between junction boxes in 1 room, place a blue identifier at least every 8 feet.
   4. Place a blue identifier on each side of where a conduit passed through a wall or other inaccessible path.

5. Identify all BAS communication conduits the same as above.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
   3. Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.
   1. Start, test, and adjust control systems.
   2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
   3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.9 SYSTEM CHECKOUT AND STARTUP

A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:
   1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
   2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
   3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.
   4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
   5. Command each relay to open and close to verify its operation.
   6. Command each 2-position damper actuator to open and close to verify operation.
   7. Command each 2-position valve to open and close to verify operation.
   8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
   9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.
   10. Test each safety device with a real life simulation, for instance check low temperature detectors with ice water, water detectors with water, etc.

C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

D. Verify that each DDC controller communicates on its respective network correctly.

E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:
   1. Start systems from DDC.
   2. Verify that each setpoint can be met by the system.
   3. Change setpoints and verify system response.
   4. Change sensor readings to verify system response.
   5. Test safety shutdowns.
   6. Verify time delays.
   7. Verify mode changes.
   8. Adjust filter switches and current switches for proper reactions.
   9. Adjust proportional bands and integration times to stabilize control loops.

F. Perform all program changes and debugging of the system for a fully operational system.

G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.10 SYSTEM COMMISSIONING, DEMONSTRATION AND TURNOVER

A. The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

B. After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

C. The BAS contractor shall fix punch list items within 30 days of acceptance.

D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.11 OPTIONAL SERVICE CONTRACT

A. The System Contractor shall, within sixty days after installation of the system begins, present a three (3) year maintenance contract for the Owner's signature. The price is to be indicated for each year with all payment terms and conditions. The contract should state that the Owner has the option to accept or

reject the second or third year contract price, given that notice of cancellation should be in writing and given not less than thirty (30) days prior to the anniversary date of the agreement.

B. The contract should state that the Owner has the option to reject the First Year Service, accepting only the System Contractor's obligation as specified herein the warranty section. System Contractor shall provide a clear comparison of warranty coverage versus First Year Service.

C. First, Second, and Third Year Service shall include the following provisions:
   1. On-Line Service - Diagnostic and troubleshooting services shall be provided via remote communications capabilities. Response time to Owner requests for this type of corrective maintenance shall be within two (2) hours.
   2. Software Maintenance and Consultation - The System Contractor shall review the need for software modifications to the existing database semi-annually, and implement modifications. Backup of the database shall be made semi-annually and retained by the System Contractor.
   3. Software Maintenance - Software revisions shall be provided as they become available.
   4. Emergency Service - The System Contractor shall provide emergency service, between scheduled preventive maintenance calls, including overtime, necessary to keep equipment and components in proper operation. When a site visit is required to complete troubleshooting procedures, the System Contractor shall be on-site within 24 hours.
   5. The System Contractor shall guarantee future availability of continuous, twenty-four hour, seven days a week service for the systems through available maintenance contracts.
   6. Service shall be performed by factory trained and employed service representatives of the System Manufacturer.
   7. Provide a basic service contract from the manufacturer of the central workstation computer, providing uniform service and parts availability.
   8. Provide a basic service contract from the manufacturer of peripherals.
   9. Preventive Maintenance shall be performed in accordance with a program of standardized maintenance routines applied to the Owner's equipment. Each schedule shall list the equipment name, location, and appropriate preventive maintenance functions to be performed during that inspection.
   10. The System Contractor shall perform regular and systematic preventive maintenance during normal working hours six (6) times per year on approximately the schedule described below. Maintenance routines shall consist of:
      a. Checking performance of equipment and components.
      b. Diagnostic test, examination, cleaning, lubrication, adjustment and calibration of equipment and their components. Such components shall include but are not limited to: Central Processing Unit, disk memory, color graphic CRT, printer, direct digital control units, printed circuit boards, and associated sensors and controllers, including all electric and electronic devices on the systems.

D. The service contract shall be renewable at the Owner's option and shall include provision for increased charges due to the expansion of the system changes, in service coverage and/or inflation.

3.12 TRAINING

A. During System commissioning and at such time as acceptable performance of the Building Automation System hardware and software has been established, the BAS contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction during normal working hours shall be performed by a competent building automation contractor representative familiar with the Building Automation System's software, hardware and accessories.

B. At a time mutually agreed upon, during System commissioning as stated above, the BAS contractor shall give 8 hours of onsite training on the operation of all BAS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:
   1. Explanation of drawings and operator's maintenance manuals.
   2. Walk-through of the job to locate all control components.
   3. Operator workstation and peripherals.
   4. DDC Controller and ASC operation/sequence.
   5. Operator control functions including scheduling, alarming, and trending.
   6. Explanation of adjustment, calibration and replacement procedures.

C. Additional 8-hours of training shall be given after the 30 day shakedown period.

D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.13 POINTS LIST

END OF 23 09 00

SECTION 23 2113 - HYDRONIC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe and pipe fittings for:
   1. Equipment drains and overflows.

B. Pipe hangers and supports.

C. Unions, flanges, mechanical couplings, and dielectric connections.

1.2 RELATED REQUIREMENTS

A. Section 08 3100 - Access Doors and Panels.

B. Section 23 0516 - Expansion Fittings and Loops for HVAC Piping.

C. Section 23 0548 - Vibration and Seismic Controls for HVAC.

D. Section 23 0553 - Identification for HVAC Piping and Equipment.

E. Section 23 0719 - HVAC Piping Insulation.

1.3 REFERENCE STANDARDS

A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators; 2017.

B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.

C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2018.

D. ASME B31.9 - Building Services Piping; 2014.

E. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005).

F. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2008 (ANSI/ASME B31.9).

G. ASTM B32 - Standard Specification for Solder Metal; 2008 (Reapproved 2014).

H. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2016.

I. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2016.

J. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2015, with Editorial Revision (2018).

K. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2015.

L. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40; 2017.

M. ASTM D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80; 2015.

N. ASTM D2855 - Standard Practice for the Two-Step (Primer & Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets; 2015.

O. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 1992,with Editiorial Revision (2018).

P. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

C. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.

B. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.8 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.1 EQUIPMENT DRAINS AND OVERFLOWS

A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn; using one of the following joint types:
   1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.

B. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.
   1. Fittings: ASTM D2466 or D2467, PVC.
   2. Joints: Solvent welded in accordance with ASTM D2855.

2.2 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58.
   1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.

B. Conform to ASME B31.9.

C. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.

D. Hangers for Cold Pipe Sizes 2 Inches and Greater: Carbon steel, adjustable, clevis.

E. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.

F. Hangers for Hot Pipe Sizes 6 Inches and Greater: Adjustable steel yoke, cast iron roll, double hanger.

G. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

H. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

I. Wall Support for Pipe Sizes 4 Inches and Greater: Welded steel bracket and wrought steel clamp.

J. Vertical Support: Steel riser clamp.

K. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

L. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

2.3 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 Inches and Less:

B. Flanges for Pipe 2 Inches and Greater:
1. Gaskets: 1/16 inch thick preformed neoprene.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment using jointing system specified.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

E. After completion, fill, clean, and treat systems. Refer to Section 23 2500 for additional requirements.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and to avoid interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Sleeve pipe passing through partitions, walls and floors.

G. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified _____.

H. Slope piping and arrange to drain at low points.

I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 22 0516.

J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 0516.

K. Grooved Joints:
   1. Install in accordance with the manufacturer's latest published installation instructions.
   2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.

L. Inserts:
   1. Provide inserts for placement in concrete formwork.

M. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
   2. Support horizontal piping as scheduled.
   3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
   4. Place hangers within 12 inches of each horizontal elbow.
   5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
   6. Prime coat exposed steel hangers and supports. Refer to Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

N. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 23 0719.

O. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

Q. Install valves with stems upright or horizontal, not inverted.

3.3 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.

B. Hanger Spacing for Steel Piping.
   1. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
   2. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
   3. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.
   4. 6 inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.
   5. 8 inches: Maximum span, 19 feet; minimum rod size, 5/8 inch.
   6. 10 inches: Maximum span, 20 feet; minimum rod size, 3/4 inch.
   7. 12 inches: Maximum span, 23 feet; minimum rod size, 7/8 inch.

END OF SECTION

SECTION 23 2300 - REFRIGERANT PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Piping.

B. Refrigerant.

C. Moisture and liquid indicators.

D. Valves.

E. Strainers.

F. Check valves.

1.2 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 09 9123 - Interior Painting.

C. Section 23 0716 - HVAC Equipment Insulation.

D. Section 23 0719 - HVAC Piping Insulation.

1.3 REFERENCE STANDARDS

A. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.

B. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants; 2013.

C. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators; 2017.

D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2018.

E. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes; 2018.

F. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2016.

G. ASME B31.9 - Building Services Piping; 2014.

H. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.

I. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2016.

J. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2016.

K. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2016.

L. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011 (Amended 2012).

M. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.4 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

B. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.

C. Liquid Indicators:
1. Use line size liquid indicators in main liquid line leaving condenser.
2. If receiver is provided, install in liquid line leaving receiver.
3. Use line size on leaving side of liquid solenoid valves.

D. Valves:
1. Use service valves on suction and discharge of compressors.
2. Use gauge taps at compressor inlet and outlet.
3. Use check valves on compressor discharge.
4. Use check valves on condenser liquid lines on multiple condenser systems.

E. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.

C. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.

D. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.

E. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.

F. Test Reports: Indicate results of leak test, acid test.

G. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.

H. Submit welders certification of compliance with ASME BPVC-IX.

I. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties in shipping containers with labeling in place.

B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.1 PIPING

A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
   1. Fittings: ASME B16.22 wrought copper.
   2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

B. Copper Tube to 7/8 inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed.
   1. Fittings: ASME B16.26 cast copper.
   2. Joints: Flared.

C. Pipe Supports and Anchors:
   1. Provide hangers and supports that comply with MSS SP-58.
      a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
   2. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
   3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   4. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
   5. Vertical Support: Steel riser clamp.
   6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
   7. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

8. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
9. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
    a. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
    b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
    c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
    d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
    e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.

2.2 REFRIGERANT

A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

B. Refrigerant: R410a as defined in ASHRAE Std 34.

2.3 MOISTURE AND LIQUID INDICATORS

A. Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

2.4 VALVES

A. Ball Valves:
    1. Two piece bolted forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.

B. Service Valves:
    1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or solder ends, for maximum pressure of 500 psi.

2.5 STRAINERS

A. Straight Line or Angle Line Type:
    1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

2.6 CHECK VALVES

A. Globe Type:

1. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc; for maximum temperature of 300 degrees F and maximum working pressure of 425 psi.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instructions.

B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.

C. Install piping to conserve building space and avoid interference with use of space.

D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

E. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.5.
   2. Support horizontal piping as indicated.
   3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
   4. Place hangers within 12 inches of each horizontal elbow.

F. Insulate piping ; refer to Section 230719.

G. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Test refrigeration system in accordance with ASME B31.5, and manufacturers recommendations.

3.4 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.

5. 2-1/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. 2-5/8 inch OD: Maximum span, 9 feet; minimum rod size, 3/8 inch.

END OF SECTION

SECTION 23 3100 - HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. Provide materials and installation for complete first class HVAC systems; install ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation that make the systems operable, code compliant and acceptable to the authorities having jurisdiction.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. ASHRAE - Handbook of Fundamentals; Duct Design.
   2. ASHRAE - Handbook of HVAC Systems and Equipment; Duct Construction.
   3. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
   4. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials.
   5. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   6. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
   7. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
   8. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate.
   9. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
   10. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
   11. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment.
   12. NFPA 45 - Laboratory Ventilating Systems and Hood Requirements.
   13. SMACNA - HVAC Duct Construction Standards.
   14. SMACNA - Rectangular Industrial Duct Construction Standards.
   15. SMACNA - Round Industrial Duct Construction Standards.
   16. SMACNA - HVAC Air Duct Leakage Test Manual.

17. UL 181 - Factory-Made Air Ducts and Connectors.
18. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
19. Assembly and Installation of Spiral Ducts and Fittings, UMC.
20. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.
21. AWSD1.1 American Welding Society Structural Welding Code.

1.4 INSTALLER QUALIFICATIONS:

A. Company shall have minimum three years documented experience specializing in performing the work of this section.

B. Installation of HVAC systems shall be performed by qualified Journeyman.

1.5 DEFINITIONS

A. Low Pressure
   1. 2 inch W.G. Pressure Class: Ductwork systems up to 2 inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.

B. Medium Pressure
   1. 3 inch W.G. Pressure Class: Ductwork systems over 2 inch w.g. and up to 3 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.

1.6 SUBMITTALS

A. Product Data:
   1. Provide the following information for each sheet metal system furnished on the Project:
      a. System name and type.
      b. Duct system design pressure.
      c. Duct material.
      d. Duct gage.
      e. Transverse joint methods.
      f. Longitudinal seam type.
      g. Sealant type.
      h. SMACNA rectangular reinforcement type.
      i. SMACNA intermediate reinforcement type.
      j. SMACNA transverse reinforcement type.

B. Record Documents:
   1. Submit Shop Drawings on all items of ductwork, plenums, and casings including construction details and accessories specified herein in accordance with Division 01. Ductwork construction details and materials used for duct sealant, flexible connections, etc. shall be submitted and approved prior to the fabrication of any ductwork.
   2. Draw ductwork Shop Drawings on minimum 1/4 inch equal to one foot scale building floor plans and shall indicate duct sizes, material, insulation type, locations of transverse joints, fittings, ductwork bottom elevation, offsets, ductwork specialties, fire and fire/smoke dampers, and other information required for coordination with other trades. Clearly designate the following on the Shop Drawings:

a. Clearance dimensions between ducts and or location dimensions from walls, floors, columns, beams and large bore piping.
b. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork pressure class ratings of ducts as defined within this specification.
c. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork.
d. Fire and fire/smoke partitions.

3. Detail Drawings for mechanical rooms and air handling unit locations shall be submitted at a minimum scale of 1/4 inch equal to one foot shall also be included within the Shop Drawings.
4. Coordinate with all other trades and building construction prior to submitting Shop Drawings for review. Indicate location of all supply, return, exhaust, and light fixtures from approved reflected ceiling plans on Shop Drawings.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver products to the Project Site and store and protect products under provisions of Division 01 and Division 20.

B. Protect materials from rust both before and after installation.

1.8 WARRANTY

A. All ductwork shown on the Drawings, specified or required for the air conditioning and ventilating systems shall be constructed and erected in a first class workmanlike manner.

B. The Work shall be guaranteed for a period of one (1) year from the Project Substantial Completion date against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Owner at Contractor's expense.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 APPLICATION

A. Ductwork systems shall be constructed in accordance with the following Materials as a minimum standard. Refer to Drawings for any deviation from this Table.

AIR SYSTEM	**MATERIAL**	**MINIMUM PRESSURE CLASSIFICATION (1)(3)**
SUPPLY AIR DISTRIBUTION	GALVANIZED STEEL	MEDIUM PRESSURE
TERMINAL UNITS TO SUPPLY AIR DEVICE	GALVANIZED STEEL (2)	LOW PRESSURE
RETURN AIR DEVICE TO RETURN DISTRIBUTION	GALVANIZED STEEL (2)	LOW PRESSURE

RETURN AIR DISTRIBUTION	GALVANIZED STEEL	MEDIUM PRESSURE
EXHAUST AIR DEVICE TO EXHAUST DISTRIBUTION (4)	GALVANIZED STEEL (2)	LOW PRESSURE
EXHAUST AIR DISTRIBUTION (4)	GALVANIZED STEEL	MEDIUM PRESSURE
GENERAL LAB EXHAUST AIR DEVICE TO HORIZONTAL DISTRIBUTION	GALVANIZED STEEL	LOW PRESSURE
KITCHEN EXHAUST FROM RESIDENTIAL EXHAUST HOOD COMMERCIAL KITCHEN EXHAUST	GALVANIZED STEEL STAINLESS STEEL	LOW PRESSURE MEDIUM PRESSURE

Notes to Table:

1. Positive pressure unless noted otherwise in Table.
2. Air device connections may be made with insulated flexible duct as specified herein.
3. Verify minimum pressure classification per NFPA 96 requirements.
4. Applies to exhaust system for general laboratory exhaust, fume hoods, and biosafety cabinets. Refer to Drawings for construction of any additional exhaust systems.

2.3 DUCTWORK MATERIAL AND CONSTRUCTION

A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.

B. Ductwork shall be constructed of G-90 coated galvanized steel of ASTM A653 and A924 Standards.

C. Minimum gage of round, oval or rectangular ductwork shall be 26 gage per SMACNA Standards.

D. All duct sizes shown on the Drawings are clear inside dimensions. Allowance shall be made for internal lining, where specified, to provide the required free area.

E. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for future connections/phases, otherwise plastic covers are acceptable.

F. Except for specific duct applications specified herein, all sheet metal shall be constructed from prime galvanized steel sheets and/or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gage.

G. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

H. Where ducts are exposed to view (including equipment rooms) and where ducts pass through walls, floors or ceilings; furnish and install sheet metal collars around the duct.

I. Duct Sealing: All ductwork, regardless of system pressure classification, shall be sealed in accordance with Seal Class A, as referenced in SMACNA Standards. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.
   1. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3 inches wide open weave fiberglass scrim tape. Sufficient additional sealant shall then be applied to completely embed the cloth.
   2. Sealant shall be water based latex UL 181A-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be Hard Cast Iron Grip 601, Ductmate Pro Seal, Foster 32-19, Childers CP-146 or Design Polymerics DP 1010.
   3. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count, similar to Hardcast FS-150.
   4. Sealer shall be rated by the manufacturer and shall be suitable for use at the system pressure classification of applicable ductwork.
   5. Except as noted, oil or solvent-based sealants are specifically prohibited.
   6. For exterior applications, “Uni-Weather” (United McGill Corporation), solvent-based sealant, or Foster 32-19 shall be used.

2.4 RECTANGULAR AND ROUND DUCTWORK

A. Metal gages listed in SMACNA HVAC Duct Construction Standards, Metal and Flexible Duct, are the minimum gages which shall be used. Select metal gage heavy enough to withstand the physical abuse of the installation. In no case shall ductwork be less than 26 gage per SMACNA Standards.

B. All longitudinal seams for rectangular duct shall be selected for the specified material and pressure classification. Seams shall be as referenced in SMACNA Standards.

C. Slip and drive duct connections are only allowed on round ductwork 6"diameter and less.

D. Longitudinal seams in laboratory hood exhaust ducts shall be welded.

E. All transverse joints and intermediate reinforcement on rectangular duct shall be as shown in SMACNA Standards. Transverse joints shall be selected consistent with the specified pressure classification, material, and other provisions for proper assembly of ductwork.

F. Spiral round duct and fittings shall be as manufactured by United McGill Sheet Metal Company or approved equivalent. All fittings shall be factory fabricated, machine formed and welded from galvanized sheet metal.

G. Joints in spiral duct and fittings shall be assembled, suspended, sealed, and taped per manufacturer’s published assembly and installation instructions.

H. Contractor may use DUCTMATE or Ward Industries coupling system, as an option, on rectangular ductwork. The DUCTMATE or Ward Industries system shall be installed in strict accordance with manufacturer's recommendations.

I. Rectangular ductwork field fabricated offsets shall not exceed 30 degrees.

2.5 FLAT OVAL DUCTWORK AND FITTINGS

A. Oval ducts shall be spiral flat oval or welded flat oval equivalent to those of United McGill Sheet Metal Company with gage and reinforcing as recommended by the manufacturer. Duct may be shop fabricated of completely welded construction in accordance with SMACNA Standards.

B. Oval ducts greater than 24 inch x 72 inch shall be longitudinal seam, flat oval duct, rolled, welded and provided in standard lengths of 5 and 10 feet. Transverse joints shall be factory welded or field connected with flanges or slip couplings. Duct will be fabricated from galvanized steel meeting ASTM A 527 standards.

C. Duct reinforcing angles shall be of sizes specified for same size rectangular duct. Galvanized angles shall be used where standing seams are specified for rectangular duct.

D. Oval fittings shall comply with requirements, sealing, etc., similar to that specified for round ductwork. Manifolding taps may be permitted without increasing the length of run in the branch duct system.

E. Elbows in oval ducts may be smooth long radius or 5-piece 90-degree elbows and 3-piece 45-degree elbows. Joints in sectional elbows shall be sealed as specified for duct sealing.

2.6 CONICAL BELLMOUTH FITTINGS AND TAPS

A. Conical bellmouth fittings shall be made from 26-gage G-90 coated galvanized steell. Two-piece construction with a minimum overall length of 6 inches and factory sealed for high-pressure requirements. Average of loss coefficient for sizes 6, 8 and 10 shall be less than 0.055.

B. Provide each fitting with minimum 24-gage damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper form rotating around shaft. Shaft shall be extended to clear insulation.

C. Provide a flange and gasket with adhesive peel-back paper for ease of application. The fittings shall be further secured by sheet metal screws spaced evenly at no more than 4 inches on center with a minimum of four (4) screws per fitting.

D. Conical bellmouth fittings shall be Series 3000G as manufactured by Flexmaster U.S.A., Inc. or Buckley Air Products, Inc., "AIR-TITE".

2.7 CASINGS AND PLENUMS - 2 INCH W.G. PRESSURE CLASS

A. All 2 inch w.g. pressure class casings and plenums for mixed air plenums shall be constructed in accordance with SMACNA Standards.

B. All casings shall enclose the filter and automatic dampers as shown on the Drawings. Casings shall be fabricated of galvanized sheet metal erected with three-foot center maximum standing seams reinforced with ¼-inch bars. The casing shall be stiffened on three-foot centers maximum with angle irons tack welded in place.

C. All openings to the casing shall be properly sealed to prevent any air leakage. Access doors shall be installed as indicated on the Drawings and shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches and #370 hinges that can be operated from both the inside and the outside.

D. Casings shall be anchored by the use of angle irons sealed and bolted to the curb and floor of the apparatus casing. Casings shall be tested and provided tight at a pressure of three inches water column.

E. Insulate per Section 23 07 13.

2.8 ELBOWS RECTANGULAR DUCTS

A. Construct elbows as follows in order of preference:
   1. Long radius, unvaned elbows.
   2. Short radius, single thickness vaned elbows.
   3. Rectangular, double thickness vaned elbows.

B. Long radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Short radius elbows shall have a centerline radius of not less than one times the duct width.

C. Contractor shall have the option to substitute short radius vaned elbows, but shall request the substitution at the time of submittal of Product Data.

D. Provide turning vanes in all rectangular elbows and offsets.

E. Job fabricated turning vanes, if used, shall be fabricated of the same gage and type of material as the duct in which they are installed. Vanes must be fabricated for same angle as duct offset. Submit Shop Drawings on factory fabricated and job fabricated turning vanes.

F. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks. In most cases, this will necessitate the installation of an angle iron support on the outside of the cheek parallel to the line of the turning vanes.

G. In 90-degree turns that are over 12 inches wide in the plane of the turn, provide and install double thickness vanes on integral side rails. For ducts under 12 inches in width, use single thickness vanes. The installation of the turning vanes shall be as described for single thickness vanes. On other types of turns or elbows, single thickness trailing edge vanes shall be used.

2.9 FLEXIBLE DUCT

A. Flexible duct shall be used where flexible duct connections are shown on the Drawings to air distribution devices and terminal units and as scheduled under “Ductwork System Applications.

B. Acoustical Flexible Duct to Diffusers, Grilles, and Terminal Units:
   1. Maximum flex duct length 6’-0” (six feet), installed with no more than 90 degrees of bend to diffusers and grilles. Where longer duct runs or more bends are necessary, provide rigid round ductwork.
   2. Maximum flex duct length 2’-0” (two feet), installed as a straight run to the inlet of the terminal units.
   3. Acoustical flexible duct shall be manufactured with an acoustically rated CPE inner film as the core fabric, mechanically locked by a corrosion-resistant galvanized steel helix.
   4. Core shall be factory pre-insulated with a total thermal performance of R-3.5 or greater. Outer jacket shall be a fire retardant polyethylene vapor barrier jacket with a perm rating not greater than 0.10 per ASTM E 96, Procedure A.
   5. Duct shall be rated for a minimum positive working pressure of 6 inches w.g. and a negative working pressure of 4 inches w.g. minimum.
   6. Temperature range shall be -20 degrees F to 250 degrees F.
   7. Duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriter's Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread less than 25; smoke developed less than 50.
   8. Acoustical flexible duct shall be similar to Flexmaster Type 8M for construction and acoustical performance standards.

C. Metal Flexible Duct:
   1. May be used for terminal unit connections from sheet metal ductwork where shown on the Drawings.
   2. Maximum length 2’-0” (two feet), installed in straight runs only. Where longer duct runs or direction changes are necessary, provide rigid round ductwork.
   3. Duct shall be constructed of 0.005 inch thick 3003-H14 aluminum alloy in accordance with ASTM B209. Duct shall be spiral wound into a tube and spiral corrugated to provide strength and flexibility.
   4. Core shall be factory pre-insulated with a total thermal performance of R-3.5 or greater. Outer jacket shall be fire retardant metalized vapor barrier jacket of fiberglass reinforced aluminum foil, with a permeance rating not greater then 0.05 per ASTM E96, Procedure A.
   5. The duct shall be rated for a minimum positive and negative working pressure of 10 inch w.g.
   6. Temperature range shall be -40 degrees F to 250 degrees F.
   7. Duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriter's Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread less than 25; smoke developed less than 50.
   8. Metal flexible duct shall be similar to Flexmaster triple lock Type TL-M.

PART 3 EXECUTION

3.1 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. Cleanliness:
   1. Before installing ductwork, wipe ductwork to a visibly clean condition.
   2. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.
   3. For ductwork supplying Clean Rooms, Operating Rooms and other Critical Care areas, sanitize ductwork with a biocidal agent EPA approved for HVAC systems immediately prior to sealing ductwork.
   4. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.

D. Provide openings in ductwork where required to accommodate thermometers, controllers and other devices. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring. Sleeve of pitot tube opening shall be no more than one inch long. Opening shall be one inch wide to accept pitot tube.

E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

F. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.

G. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.

H. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

I. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel for ducts where concealed.

J. All visible welds in ductwork between biosafety cabinets, canopy hoods and fume hoods and the ceiling shall be ground and polished.

K. Slope duct toward grilles for moisture-laden ducts. Provide drain and trap at elbow of main moisture exhaust duct system.

L. Project inspector shall be notified to inspect all field fabricated offsets before cover-up or external insulation is applied.

M. Flexible Duct:
1. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp.
2. Fittings on terminal units and on sheet metal duct shall have flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts terminal unit or insulation on duct.
3. These insulation connections shall be sealed by embedding fiberglass tape in the sealant and coating with more sealant to provide a vapor barrier.

N. Support flexible ducts as per SMACNA standards to prevent sags, kinks and to have 90 degree turns.

O. Hangers and Supports:
1. All ductwork supports shall be in accordance with Table 4-1 (rectangular duct) and Table 4-2 (round duct) of the SMACNA Standards, with all supports directly anchored to the building structure.
2. Rectangular duct shall have at least one pair of supports on minimum 8'-0" (eight feet) centers. All horizontal round and flat oval ducts shall have ducts hangers spaced 10'-0" (ten feet) maximum.
3. Lower attachment of hanger to duct shall be in accordance with Table 4-4 of the SMACNA Standards.
4. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2 inch x 1-1/2 inch x 1/4 inch angles for duct widths up to 60 inches. Above 60 inches in width, the angles must be increased in strength and sized on an individual basis considering space requirements.
5. Hanger straps on duct widths 60 inches and under shall lap under the duct a minimum of 1 inch and have minimum of one fastening screw on the bottom and two on the sides.
6. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8 inch bolts minimum.

3.2 DUCTWORK SYSTEM CLEANING

A. If the system has been operated without scheduled filters or if the integrity of temporary closures has been compromised, Contractor shall have ductwork cleaned according to National Air Duct Cleaners Association (NADCA) Standards by a Certified Regular Member of the NADCA.

B. Before turning the installation over to the Owner, Contractor shall certify that the air handling systems have only been operated with scheduled filters in place. Otherwise, Contractor shall present evidence that the ductwork was cleaned as required above.

3.3 TESTING

A. All medium and high pressure duct systems (positive or negative) shall be pressure tested according to SMACNA test procedures (HVAC Air Duct Leakage Test Manual). Notify Owner minimum seven (7) calendar days in advance of leakage testing.
1. Design pressure for testing ductwork shall be determined from the maximum pressure generated by the fan at the nominal motor horsepower selected.

2. Total allowable leakage shall not exceed 1 percent of the total system design airflow rate.
3. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
4. Leaks identified during leakage testing shall be repaired by:
    a. Complete removal of the sealing materials.
    b. Thorough cleaning of the joint surfaces.
    c. Installation of multiple layers of sealing materials.
5. The entire ductwork system shall be tested, excluding connections upstream of the terminal units (i.e. ductwork shall be capped immediately prior to the terminal units, and tested as described above).
6. After testing has proven that ductwork is installed and performs as specified, the terminal units shall be connected to ductwork and connections sealed with extra care. Contractor shall inform the Owner when joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage exists in the terminal unit connections/joints after the systems have been put into service, leaks shall be repaired as specified for other leaks.
7. Fixed flow measurement devices (i.e. orifice tubes, nozzles, etc.) shall have current calibration documentation showing that the device was verified to a National Institute Of Standards and Technology (NIST) standard within the previous five years or as recommended by the manufacture and be accurate to at least +/- 2% of reading.
8. Pressure measurement instrumentation (i.e. manometer) shall have current calibration documentation showing that the device was verified to a NIST standard within the previous year or as recommended by the manufacture. Instrumentation shall have an accuracy of at least +/- 2% of reading and have a resolution of 2:1 with respect to the measured pressure (i.e. resolution of 0.01 measured 0.1).

B. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.
    1. Leaks identified by inspection shall be repaired by:
        a. Complete removal of the sealing materials.
        b. Thorough cleaning of the joint surfaces.
        c. Installation of multiple layers of sealing materials.
    2. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

C. At the option of the Owner, if documented in writing, Contractor may be allowed to eliminate testing of terminal units by capping the supply ductwork prior to the terminal units, then inspecting the connection to the terminal units when complete. This option may only be exercised by the Owner, only if documented in writing prior to testing.]

D. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

END OF SECTION

SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air turning devices/extractors.

B. Backdraft dampers - metal.

C. Backdraft dampers.

D. Duct access doors.

E. Duct test holes.

F. Flexible duct connectors.

G. Volume control dampers.

1.2 RELATED REQUIREMENTS

A. Section 23 0548 - Vibration and Seismic Controls for HVAC.

B. Section 23 3100 - HVAC Ducts and Casings.

C. Section 23 3600 - Air Terminal Units: Pressure regulating damper assemblies.

1.3 REFERENCE STANDARDS

A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2018.

B. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Revised 2009).

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.

C. Manufacturer's Installation Instructions: Provide instructions for fire dampers.

D. Project Record Drawings: Record actual locations of access doors and test holes.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.1 AIR TURNING DEVICES/EXTRACTORS

A. Manufacturers:
1. Krueger-HVAC, Division of Air System Components; _____: www.krueger-hvac.com/#sle.
2. PCI Industries, Inc; Pottorff Brand : www.portorff.com.
3. Ruskin Company; _____: www.ruskin.com/#sle.
4. Titus HVAC, a brand of Johnson Controls; _____: www.titus-hvac.com/#sle.
5. Substitutions: See Section 01 6000 - Product Requirements.

B. Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

2.2 BACKDRAFT DAMPERS

A. Manufacturers:
1. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
3. Ruskin Company; _____: www.ruskin.com/#sle.
4. Substitutions: See Section 01 6000 - Product Requirements.

B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.3 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA (DCS) and as indicated.

B. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
1. Less Than 12 inches Square: Secure with sash locks.
2. Up to 18 inches Square: Provide two hinges and two sash locks.
3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
4. Larger Sizes: Provide an additional hinge.

C. Access doors with sheet metal screw fasteners are not acceptable.

2.4 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

1. Manufacturers:
2. Carlisle HVAC Products; Dynair Test Port with Red Cap with O-Ring Seal: www.carlislehvac.com/#sle.

2.5 FLEXIBLE DUCT CONNECTORS

A. Manufacturers:
   1. Carlisle HVAC Products; Dynair Connector Plus G90 Steel Offset Seam Neoprene Fabric: www.carlislehvac.com/#sle.
   2. Substitutions: See Section 01 6000 - Product Requirements.

B. Fabricate in accordance with SMACNA (DCS) and as indicated.

C. Flexible Duct Connections: Fabric crimped into metal edging strip.
   1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.
      a. Net Fabric Width: Approximately 2 inches wide.
   2. Metal: 3 inches wide, 24 gage, 0.0239 inch thick galvanized steel.

2.6 VOLUME CONTROL DAMPERS

A. Manufacturers:
   1. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
   2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
   3. Ruskin Company; _____: www.ruskin.com/#sle.
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Fabricate in accordance with SMACNA (DCS) and as indicated.

C. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

E. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

F. Quadrants:
   1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
   2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
   3. Where rod lengths exceed 30 inches provide regulator at both ends.

PART 3 EXECUTION

3.1 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 3100 for duct construction and pressure class.

B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated. Provide 4 x 4 inch Review locations prior to fabrication.

D. Provide duct test holes where indicated and required for testing and balancing purposes.

E. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.

F. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.

G. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

H. Provide air turning devices within duct whenever long radius elbows are not utilized.

END OF SECTION

SECTION 23 3319 - DUCT SILENCERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Duct silencers.

1.2 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance.

C. Shop Drawings: Indicate assembly, materials, thicknesses, dimensional data, pressure losses, acoustical performance, layout, and connection details.

D. Manufacturer's Installation Instructions: Indicate installation procedures necessary to maintain integrity of sound isolation.

E. Manufacturer's Field Reports: Indicate installation is complete and in accordance with instructions.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.1 DUCT SILENCERS

A. Manufacturers:
1. Price Industries, Inc; : www.priceindustries.com/#sle.
2. IAC

B. Description: Duct section with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction. Fabricate in accordance with SMACNA (DCS) HVAC Duct Construction Standards.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Support duct silencers rigidly to ducts _____. Refer to Section 23 3100 and Section 23 3300.

END OF SECTION

SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Wall exhausters.

B. Upblast roof exhausters.

1.2 RELATED REQUIREMENTS

A. Section 23 0513 - Common Motor Requirements for HVAC Equipment.

B. Section 23 0548 - Vibration and Seismic Controls for HVAC.

C. Section 23 3300 - Air Duct Accessories: Backdraft dampers.

D. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

A. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2017.

B. UL 705 - Power Ventilators; Current Edition, Including All Revisions.

C. UL 762 - Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate the installation of equipment with size, location and installation of service utilities.

B. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.

C. Manufacturer's Instructions: Indicate installation instructions.

D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Fan Belts: One set for each individual fan.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.7 FIELD CONDITIONS

A. Permanent ventilators may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Greenheck Fan Corporation; : www.greenheck.com/#sle.

2.2 ROOF EXHAUSTERS (GENERAL PURPOSE)

A. Manufacturers:
   1. Carnes, a division of Carnes Company Inc: www.carnes.com/#sle.
   2. Greenheck Fan Corporation: www.greenheck.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.

C. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.

D. Roof Curb: 8 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.

E. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor and wall mounted multiple speed switch.

F. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.

G. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.3 WALL EXHAUSTERS

A. Fan Unit: V-belt or direct driven with spun aluminum housing; resiliently mounted motor; 1/2 inch mesh, 0.062 inch thick aluminum wire bird screen.

B. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.

C. Sheaves: For V-belt drives, provide cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.4 UPBLAST ROOF EXHAUSTERS

A. Manufacturers:
   1. Carnes, a division of Carnes Company Inc; VUDK: www.carnes.com/#sle.
   2. Greenheck Fan Corporation: www.greenheck.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Direct Drive Fan:
   1. Fan Wheel:
      a. Type: Non-overloading, backward inclined centrifugal.
      b. Material: Aluminum.
   2. Statically and dynamically balanced.
   3. Motors:
      a. Open drip-proof (ODP).
      b. Heavy duty ball bearing type.
      c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
      d. Fully accessible for maintenance.
   4. Housing:
      a. Construct of heavy gage aluminum including curb cap, windband, and motor compartment.
      b. Rigid internal support structure.
      c. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
      d. Construct drive frame assembly of heavy gage steel, mounted on vibration isolators.
      e. Provide breather tube for fresh air motor cooling and wiring.

C. Shafts and Bearings:
   1. Fan Shaft:
      a. Ground and polished steel with anti-corrosive coating.
      b. First critical speed at least 25 percent over maximum cataloged operating speed.
   2. Bearings:
      a. Permanently sealed or pillow block type.
      b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
      c. 100 percent factory tested.

D. Drive Assembly:
   1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
   2. Belts: Static free and oil resistant.
   3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
   4. Motor pulley adjustable for final system balancing.
   5. Readily accessible for maintenance.

E. Drain Trough: Allows for single-point drainage of water, grease, and other residues.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.

C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.

D. Provide sheaves required for final air balance.

E. Install backdraft dampers on inlet to roof and wall exhausters.

END OF SECTION

SECTION 23 3700 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Diffusers:

B. Registers/grilles:

C. Louvers:

1.2 REFERENCE STANDARDS

A. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets; 2006 (Reaffirmed 2011).

1.3 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

C. Project Record Documents: Record actual locations of air outlets and inlets.

1.4 QUALITY ASSURANCE

A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.

PART 2 PRODUCTS

2.1 GRD MANUFACTURERS (SEE DRAWINGS FOR MODELS)

A. Price Industries: www.price-hvac.com/#sle.

B. Titus, a brand of Air Distribution Technologies: www.titus-hvac.com/#sle.

C. Tuttle and Bailey: www.tuttleandbailey.com/#sle.

D. Substitutions: See Section 01 6000 - Product Requirements.

2.2 LOUVER MANUFACTURERS (SEE DRAWINGS FOR MODELS)

A. Greenheck

B. Ruskin

C. Substitutions: See Section 01 6000 - Product Requirements

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with air tight connection.

D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

E. Paint ductwork visible behind air outlets and inlets matte black.

F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9123.

END OF SECTION

SECTION 23 4000 - HVAC AIR CLEANING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Disposable, extended area panel filters.

B. Filter gauges.

1.2 RELATED REQUIREMENTS

A. Section 01 5000 - Temporary Facilities and Controls: Filters for temporary heating and ventilating.

1.3 REFERENCE STANDARDS

A. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2017.

B. UL 900 - Standard for Air Filter Units; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.

C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Filters: One set of each type and size.

1.5 QUALITY ASSURANCE

A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 FILTER MANUFACTURERS

A. American Filtration Inc; _____: www.americanfiltration.com/#sle.

B. AAF International/American Air Filter; _____: www.aafintl.com/#sle.

C. The Camfil Group; _____: www.camfilfarr.com/#sle.

D. Substitutions: See Section 01 6000 - Product Requirements.

2.2 DISPOSABLE, EXTENDED AREA PANEL FILTERS

A. Media: UL 900 Class 1, pleated, lofted, non-woven, reinforced cotton fabric; supported and bonded to welded wire grid by corrugated aluminum separators.
   1. Frame: Non-flammable.
   2. Nominal size: 12 by 24 inches.
   3. Nominal thickness: 1 inch.

B. Minimum Efficiency Reporting Value (MERV): 8, when tested in accordance with ASHRAE Std 52.2.

C. Rating, per ASHRAE Std 52.2:
   1. Weight arrestance: 85 percent.
   2. Initial resistance at 500 FPM face velocity: 0.20 inch WG.
   3. Recommended final resistance: 0.9 inch WG.

2.3 FILTER GAUGES

A. Manufacturers:
   1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
   2. H.O. Trerice Co; _____: www.trerice.com/#sle.
   3. Weiss Instruments; _____: www.weissinstruments.com/#sle.
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0-0.5 inch WG, 2 percent of full scale accuracy.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install air cleaning devices in accordance with manufacturer's instructions.

B. Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.

C. Install filter gauge static pressure tips upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.

E. Provide filter gauges on filter banks, installed with separate static pressure tips upstream and downstream of filters.

END OF SECTION

SECTION 23 5100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Catagory IV appliance venting

B. Type B double wall gas vents.

C. Double wall metal stacks.

1.2 REFERENCE STANDARDS

A. ANSI Z21.66 - American National Standard for Automatic Damper Devices for Use with Gas-Fired Appliances; 2015.

B. NFPA 54 - National Fuel Gas Code; 2018.

C. NFPA 82 - Standard on Incinerators and Waste and Linen Handling Systems and Equipment; 2014.

D. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances; 2016.

E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Revised 2009).

F. UL 103 - Factory-Built Chimneys for Residential Type and Building Heating Appliances; Current Edition, Including All Revisions.

G. UL 441 - Standard for Gas Vents; Current Edition, Including All Revisions.

1.3 DEFINITIONS

A. Breeching: Vent connector.

B. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.

C. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.

C. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations where factory built units are used.

D. Manufacturer's Instructions: Include installation instructions, and indicate assembly, support details, and connection requirements.

1.5 REGULATORY REQUIREMENTS

A. Conform to NFPA 54 for installation of natural gas burning appliances and equipment.

B. Conform to applicable code for installation of oil burning appliances and equipment.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. AMPCO by Hart & Cooley, Inc; Model VSI: www.ampcostacks.com/#sle.

B. DuraVent; DuraStack Pro (DIS2): www.duravent.com/#sle.

C. Metal-Fab, Inc; _____: www.mtlfab.com/#sle.

D. Selkirk Corporation; Model PS: www.selkirkcommercial.com/#sle.

E. Substitutions: See Section 01 6000 - Product Requirements.

2.2 BREECHINGS, CHIMNEYS, AND STACKS - GENERAL REQUIREMENTS

A. Regulatory Requirements:
   1. Comply with applicable codes for installation of natural gas burning appliances and equipment.
   2. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.3 FIELD FABRICATED BREECHINGS

A. AL29-4C stainless steel for venting category IV appliances shall be:
   1. Vent shall be constructed with an inner conduit constructed of AL29-4C® superferritic stainless steel with a minimum thickness that shall meet or exceed the requirements of UL 1738.
   2. Products furnished under this section shall conform to the requirements of NFPA 54 and NFPA 211, and shall comply with UL 1738, Standard for Venting Systems for Category II, III, and IV Gas-Burning Appliances, and all other applicable standards.
   3. All inner wall conduit components shall be manufactured from AL29-4C®. The closure system shall be a Ring-and-Tab mechanical closure system that is integral to the system.
   4. Joints to be sealed with factory supplied sealant. Joints shall be designed to minimize collection of condensate in both horizontal and vertical runs. Joints shall not use screws or other lesser alloy fasteners that penetrate the inner conduit.

5. The outer wall casing shall be constructed of 430 stainless steel that shall not require additional surface preparation, such as painting, in order to withstand the outdoors or high humidity environments.
6. Inner conduit and outer wall casing shall be constructed in a fashion which prevents cross-alloy contamination and allows free movement between the two, allowing for varying rates of expansion and contraction to occur.
7. System is to be sized in accordance with the appliance manufacturer's specifications.

B. PVC for venting and make up air of catagory IV appliances shall be:
1. PVC Schedule 40 pipe manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D1785 and D2665, consistently meeting and/or exceeding the Quality Assurance test requirements of these standards with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer.
2. Joined with PVC solvent - IPS Weld-On 724.
3. The plastic components, primers and glues of the vent system must be from a single system manufacturer and not inter-mixed with other manufacturers vent system parts.
4. Painted with a water based paint to protect the piping exposed to UV rays (outside).

2.4 TYPE B DOUBLE WALL GAS VENTS

A. Fabrication: Inner pipe of sheet aluminum, and outer pipe of galvanized sheet steel, tested in compliance with UL 441.

B. Electrically Actuated Vent Dampers: Same size as draft hood collar, constructed of stainless steel or galvanized steel, with corrosion-resistant components, in compliance with ANSI Z21.66.

2.5 DOUBLE WALL METAL STACKS

A. Provide double wall metal stacks, tested to UL 103 and UL listed with positive pressure rating, for use with building heating equipment, in compliance with NFPA 211.

B. Fabricate with 1 inch minimum air space between walls and construct inner liner of 304 stainless steel and outer jacket of AL29-4C stainless steel.
1. Protect aluminized steel surfaces exposed to the elements with a minimum of one base coat of primer and one finish coat of corrosion resistant paint suitable for outer jacket skin temperatures of the application.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 54.

C. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.

D. Support breechings from building structure, rigidly with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA (DCS) for equivalent duct support configuration and size.

E. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.

F. For Type B double wall gas vents, maintain UL listed minimum clearances from combustibles. Assemble pipe and accessories as required for complete installation.

G. Assemble and install stack sections in accordance with NFPA 82, industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement. Connect base section to foundation using anchor lugs.

H. Level and plumb chimney and stacks.

I. Clean breechings, chimneys, and stacks during installation, removing dust and debris.

END OF SECTION

SECTION 23 7413 - PACKAGED ROOFTOP AIR CONDITIONING UNITS

GENERAL

1.1 SECTION INCLUDES

A. Package roof top unit.

B. Heat exchanger.

C. Refrigeration components.

D. Unit operating controls.

E. Roof curb.

F. Electrical power connections.

G. Operation and maintenance service.

1.2 REFERENCES

A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

C. AHRI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard.

D. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.

E. ANSI/ASHRAE/IESNA 90.1- Energy Standard for New Buildings Except Low-Rise Residential Buildings.

F. ANSI Z21.47 - Unitary Air Conditioning Standard for safety requirements.

G. California Energy Commission Administrative Code - Title 20/24 - Establishes the minimum efficiency requirements for HVAC equipment installed in new buildings in the State of California.

H. AHRI 210/240 - Unitary Air-Conditioning Equipment and Air- Source Heat Pump Equipment.

I. AHRI 270 - Sound Rating of Outdoor Unitary Equipment.

J. AHRI 370 - Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment.

K. ANSI/NFPA 70 - National Electric Code.

1.3 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

E. Shop drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

1.4 DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory-shipping covers in place until installation.

1.5 WARRANTY

A. Provide parts and labor warranty (excluding refrigerant) for 24 months from start-up.

B. Provide five-year extended warranty for compressors.

C. Provide five-year heat exchanger limited warranty.

1.6 REGULATORY REQUIREMENTS

A. Unit shall conform to ANSI Z21.47/UL1995 for construction of packaged air conditioner
   1. In the event the unit is not UL approved, the manufacturer must, at his expense, provide for a field inspection by a UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative, at no additional expense to the Owner.

1.7 EXTRA MATERIALS

A. Provide one set of filters.

B. Furnish a complete set of fan motor drive belts.

PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install package rooftop unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. APPROVED MANUFACTURERS
   1. Contractor to provide pricing for both of the following:
      a. Basis of Design: Trane
      b. Alternate: Daikin Applied (equivalent to Trane selections listed in design drawings)

2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be Trane Precedent packaged rooftop as scheduled on contract documents and these specifications. Cooling capacity ratings shall be based on AHRI Standard. Unit(s) shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, return-air filters, supply motors and unit controls

B. Unit(s) shall be 100% factory run tested and fully charged with R-410A

C. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

D. Units shall be convertible airflow design as manufactured.

E. Wiring internal to the unit shall be colored and numbered for identification.

2.3 UNIT CASING

A. Cabinet: Galvanized steel, phosphatized, and finished with an air-dry paint coating with removable access panels. Structural members shall be 18 gauge with access doors and removable panels of minimum 20 gauge.

B. Units cabinet surface shall be tested 1000 hours in salt spray test in compliance with ASTM B117.

C. Cabinet construction shall allow for all service/ maintenance from one side of the unit.

D. Cabinet top cover shall be one piece construction or where seams exits, it shall be double-hemmed and gasket-sealed.

E. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section.

F. Units base pan shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity.

G. Insulation: Provide 1/2 inch thick fiberglass insulation with foil face on all exterior panels in contact with the return and conditioned air stream. All edges must be captured so that there is no insulation exposed in the air stream.

H. Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.

I. The base of the unit shall have 3 sides for forklift provisions. The base of the units shall have rigging/lifting holes for crane maneuvering.

2.4 AIR FILTERS

A. Air Filters: Factory installed filters shall mount integral within the unit and shall be accessible through access panels. One-inch thick glass fiber disposable media filters shall be provided with the provisions within the unit for 2 inch thick filters to be field- provided and installed.

2.5 FANS AND MOTORS

A. Provide evaporator fan section with forward curved, double width, double inlet, centrifugal type fan.

B. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings.

C. Provide units 5 tons and below with direct drive, multiple speed, dynamically balanced supply fans.

D. Provide units 6 tons and above with belt driven, supply fans with adjustable motor sheaves.

E. Outdoor and Indoor Fan Motors shall be permanently lubricated and have internal thermal overload protection.

F. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.

G. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.6 GAS FIRED HEATING SECTION

A. Completely assembled and factory installed heating system shall be integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided. Provide capability for gas piping <<CONNECTION>>.

B. Heating section shall be factory run tested prior to shipment.

C. Induced draft combustion type with direct spark ignition system, redundant main gas valve, and 2-staged heat.

D. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Provide flame rollout switches.

E. Induced draft blower shall have combustion air proving switches and built-in thermal overload protection on fan motor.

F. Burners: Burners shall be of the in-shot type constructed of stainless steel.

G. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.

2.7 EVAPORATOR COIL

A. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.

B. Provide an independent expansion device for each refrigeration circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

C. Provide a removable, reversible, cleanable double sloped drain pan for base of evaporator coil constructed of PVC.

2.8 CONDENSER SECTION

A. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

2.9 REFRIGERATION SYSTEM

A. Compressor(s): Provide scroll compressor with direct drive operating at 3600 rpm. Integral centrifugal oil pump. Provide suction gas cooled motor with winding temperature limits and compressor overloads.

B. Units shall have cooling capabilities down to 0 degree F as standard. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.

C. Provide each unit with refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, suction and liquid line pressure ports.

D. For heat pump units, provide reversing valve, discharge muffler, flow control check valve, and electronic adaptive demand defrost control on all units.

2.10 EXHAUST/RETURN SECTION

A. Provide, on downflow units above 6 tons, a factory supplied field installed power exhaust assembly that shall assist the barometric relief damper in the economizer in relieving building pressurization.

2.11 OUTDOOR AIR SECTION

A. Provide 100% return air.

B. Provide economizer with enthalpy control

C. Provide adjustable minimum position control located in the economizer section of the unit.

D. Provide spring return motor for outside air damper closure during unit shutdown or power interruption.

2.12 OPERATING CONTROLS

A. Provide microprocessor unit-mounted DDC control which when used with an electronic zone sensor provides proportional integral room control. This UCM shall perform all unit functions by making all heating, cooling, and ventilating decisions through resident software logic.

B. Provide factory-installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation.

C. Provide an anti-cycle timing and minimum on/off between stages timing in the microprocessor.

D. Economizer Preferred Cooling (if supplied with economizer) - Compressor operation is integrated with economizer cycle to allow mechanical cooling when economizer is not adequate to satisfy zone requirements. Compressors are enabled if space temperature is recovering to cooling setpoint at a rate of less than 0.2 degrees per minute. Compressor low ambient lockout overrides this function.

2.13 STAGING CONTROLS

A. Provide NEC Class II, electronic, adjustable zone control to maintain zone temperature setting, Model.

B. Provide programmable electronic microcomputer based zone control.
   1. Zone control shall incorporate:
      a. Automatic changeover from heating to cooling.
      b. Set-up for at least 2 - sets of separate heating and cooling temperatures per day.
      c. Instant override of setpoint for continuous or timed period from one hour to 31 days.
      d. Switch selection features including Fahrenheit display, 12 or 24-hour clock, keyboard disable, remote sensor, fan on-auto.
      e. Smart Fan Operation: Allows the unit fan operation to default to the Auto Mode during unoccupied periods, regardless of the Fan switch position.
      f. Economizer Minimum Position Override: Allows the unit controller to override and close the minimum position setting on the economizer damper during unoccupied time periods.
   2. Zone sensor display shall be capable of:
      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 indication: heating, cooling, low battery, and fan on.

C. Provide remote temperature sensor capability.

D. Provide mixed air sensor in supply air to close outside air damper.

2.14 BUILDING MANAGEMENT SYSTEM

A. Interface control module to Energy Management System to be furnished and mounted by rooftop unit manufacturer. Through this interface module, all Energy Management functions (specified in Energy Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). If not furnished by rooftop unit manufacturer, this shall be furnished by Energy Management System Contractor for factory mounting by rooftop unit manufacturer in rooftop unit and rated for service up to 140 F. The only field connection to Energy Management System shall be a single communication link.

B. Control Functions: Include unit scheduling, occupied/unoccupied mode, start-up and coast-down modes, nighttime free-cool purge mode, demand limiting, night setback, discharge air set point adjustment, timed override and alarm shutdown

C. Diagnostic Functions: Include supply fan status,

D. Provide capabilities for Boolean Processing and trend logs as well as "templated" reports and logs.

2.15 ROOF CURB

A. Contractor shall provide 14" tall factory supplied roof curb, 16 gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly.

B. Top of all roof curbs shall be level, with pitch built into curb when deck slopes

C. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

EXECUTION

3.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work and opening dimensions

B. Contractor shall verify that proper power supply is available.

3.2 INSTALLATION

A. Contractor shall install in accordance with manufacturer's instructions.

B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

3.3 MANUFACTURER'S FIELD SERVICES

A. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

3.4 SEQUENCE OF OPERATIONS

3.5 PACKAGED ROOFTOP UNITS (RTU)

A. Microprocessor controller - Each RTU shall be controlled by a stand-alone microprocessor based controller with resident control logic. The controller will interface with the BAS and the inputs and outputs in the points list to accomplish the following temperature control and energy conservation strategies.
   1. Occupied Mode - All unit functions will be enabled for normal heating and cooling operation. Unit defaults to default temperature setpoints in the unit microprocessor when communication with BAS is lost.
   2. Occupied Space Temperature Control - When in occupied mode as described above, the dedicated unit control shall operate stages of heating and cooling to maintain space temperature setpoint. Setpoints may be set by one of the following methods:
      a. Remotely through BAS by the system operator;
      b. Locally through the thermostat by the occupant;
      c. Locally through the thermostat by the occupant within limits defined through the BAS by the system operator;
      d. Operator may designate wild card setpoints to apply to any or all of the RTU's through the BAS.

B. Optimal Start Mode - When the unit is turned on by the BAS for optimal start, heating or cooling is provided as required. The outside air dampers, if provided, remains closed, in heating mode or mechanical cooling mode, until occupied time. Economizer cycle, if supplied, will be available if required.

C. Coastdown Mode - When the unit is turned "OFF" by the BAS for optimal stop, the supply fan remains "ON/AUTO", the outside air damper remains in minimum position for ventilation, and utilizes the unoccupied setpoints.

D. Demand Limit Mode - Through the BAS a user defined Demand Limit Mode shall be available. User defines maximum off time and temperature to ensure occupant comfort.

E. Night Setback Temperature Control - When the BAS selects unoccupied mode, the unit shall be controlled to maintain user defined unoccupied heating and cooling setpoints. Adjustable start and stop temperature differentials will prevent short cycling. The outdoor air damper remains closed during heating night setback operation, if provided.

F. Economizer - Each RTU when equipped will measure and select lowest total heat air stream to meet cooling demands. When using return air, the outside air damper will be position at a minimum position. The minimum position will be adjustable by the operator or through the BAS software.

G. Nighttime Free-Cool Purge Mode - An "economizer only" cooling cycle shall be provided during unoccupied hours when outdoor air conditions are suitable and the zone requires cooling.

H. Low Ambient Compressor Lockout - Compressor operation shall be disabled below a user defined outdoor air temperature.

I. Timed Override - When a timed override is initiated by the user, the unit will return to its user defined normal occupied mode for the user determined period of time.

J. Fire Shutdown - The unit will shut down in response to a customer supplied contact closure to the BAS indicating the presence of a fire or other emergency condition.

K. Unit status report - For each RTU unit, the BAS shall provide an operating status summary of all sensed values (zone temperature, discharge temperature, etc.) setpoints and modes.

L. Supply Air Tempering - When the unit is in the heat mode, but not actively heating, if the supply air temperature drops 10 degrees or more below the heating setpoint, heat is turned on until supply air temperature rises to a point 10 degrees above the heating setpoint.

M. Alternating Lead/Lag - (Dual Compressors Models Only), During periods of part load operation, each compressor cycles alternatively as circuit number one in order to equalize wear and run time.

N. Economizer Preferred Cooling - Compressor operation is integrated with economizer cycle to allow mechanical cooling when economizer is not adequate to satisfy zone requirements. Compressors are enabled if space temperature is recovering to cooling setpoint at a rate of less than 0.2 degrees pe rminute. Compressor low ambient lockout overrides this function.

O. Diagnostic/Protection - The BAS system shall be able to alarm from all sensed points from the rooftop units and diagnostic alarms sensed by the unit controller. Alarm limits shall be designated for all sensed points.

END OF SECTION

SECTION 23 7414 - DEDICATED OUTDOOR AIR UNITS (PACKAGED)

GENERAL

1.1 SECTION INCLUDES

A. Packaged outdoor air unit.
   1. Dehumidification/Cooling.
   2. Heating.
   3. Electrical Ratings and Connections
   4. Unit Controls
   5. Powered Exhaust
   6. Energy Recovery
   7. Roof curb

B. REFERENCES
   1. (AHRI has introduced Standard 920 “Performance Rating of DX Dedicated Outdoor Air System Units”. Testing for rating is next step in implementation of this rating standard.)
   2. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration. (all)
   3. ANSI/ASHRAE/IESNA 90.1-2013 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.
   4. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.
   5. ANSI/NFPA 70-1995 - National Electric Code. (all)
   6. International Fuel Gas Code (g/e)
   7. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems. (all)
      a. SUBMITTALS
   8. Submit unit performance data including: capacity, nominal and operating performance.
   9. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
   10. Submit drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
   11. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.
   12. Drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

C. DELIVERY, STORAGE and HANDLING
   1. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
   2. Protect units from physical damage. Leave factory shipping covers in place until installation.
   3. Units to be secured via base rail tie-down locations.

D. WARRANTY
   1. Provide parts and labor warranty extending either 24-months from date of unit start-up.

2. Provide twenty-five year heat exchanger limited warranty from unit ship date.
3. 5 year compressor warranty for units 25 tons and below.

E. REGULATORY REQUIREMENTS
1. Unit shall conform to the appropriate standards listed in Section 103 as well as be listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) for compliance with the following applicable standards.
   a. Standard for Safety Heating and Cooling Equipment-Fourth Edition, UL 1995/CSA C22.2#236 Issue: 2011/10/14
   b. Standard for Gas Unit Heaters And Gas-Fired Duct Furnaces ANSI Z83.8-2013, CSA 2.6-2013, Third Edition – 2006 (indirect gas-fired/e)
   c. Standard for Non-Recirculating Direct Gas-Fired Industrial Air Heaters, ANSI Z83.4 / CSA 3.7 - Issued: 2013/03/01 Ed: 3
   d. In the event the unit is not approved by an NRTL for compliance with the appropriate standards, the manufacturer shall, at manufacturer's expense, provide for a field certification and labeling of unit by an NRTL to the appropriate standards. Manufacturer shall, at manufacturer's cost, complete any and all modifications required by NRTL prior to certification and field labeling. Manufacturer shall include coverage of all modifications in unit warranty.

F. EXTRA MATERIALS
1. Provide one set of filters.

PRODUCTS

2.1 SUMMARY

2.2 THE CONTRACTOR SHALL FURNISH AND INSTALL PACKAGED OUTDOOR AIR UNIT(S) AS SHOWN AND SCHEDULED ON THE CONTRACT DOCUMENTS. THE UNIT(S) SHALL BE INSTALLED IN ACCORDANCE WITH THIS SPECIFICATION AND PERFORM AT THE SPECIFIED CONDITIONS AS SCHEDULED.

2.3 APPROVED MANUFACTURERS

A. Contractor to provide pricing for both of the following:
1. Basis of Design: Trane
2. Alternate: Daikin Applied (equivalent to Trane selections listed in design drawings)

B. GENERAL UNIT DESCRIPTION
1. Unit(s) furnished and installed shall be packaged outdoor air unit(s) as scheduled on contract documents and described in these specifications. Unit(s) shall be designed for dehumidification, cooling and/or heating of 100% Outdoor Air. For dehumidification and cooling modes the evaporator temperature shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point. Hot Gas Bypass shall not be used to control compressor capacity. Compressor Hot Gas Reheat (HGRH) shall be factory installed. To prevent rehydration of evaporator condensate the reheat coil face shall be located a minimum of 6" downstream from the leaving face of the evaporator coil. Heating system shall include modulating

controls. Compressor on-off only or primary heating on-off only controls shall not be acceptable control strategies.

2. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
3. Unit discharge airflow configuration shall be:
   a. Vertical discharge thru unit base.
   b. Horizontal discharge thru unit roof curb.
   c. Horizontal discharge through side of unit.
      1) CABINET

2.4 CABINET PANELS: 2" DOUBLE-WALL FOAMED PANEL CONSTRUCTION THROUGHOUT THE INDOOR SECTION OF UNIT TO PROVIDE NONPOROUS, CLEANABLE INTERIOR SURFACES. ALL INTERIOR SEAMS EXPOSED TO AIRFLOW SHALL BE SEALED.

A. Insulation: 2" polyisocyanurate foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.

B. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2" thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

2.5 CABINET BASE RAILS: SIDE AND END BASE RAILS SHALL INCLUDE OPENINGS FOR FORKLIFT AND TIE-DOWN ACCESS. TO PROTECT UNIT BASE FROM FORK DAMAGE SIDE RAILS SHALL INCLUDE REMOVABLE HEAVY GAUGE FORK POCKETS.

2.6 SHIPPING ANCHORS ATTACH TO AND/OR THROUGH UNIT BASE RAILS. STRAPS OVER UNIT SHALL NOT BE USED TO SECURE UNIT FOR SHIPPING.

2.7 CABINET MATERIAL INTERIOR AND BASE RAILS: SHALL BE G-90 ZINC-COATED GALVANIZED STEEL. MATERIAL GAUGE SHALL BE A MINIMUM OF 14-GAUGE FOR BASE RAILS, 16-GAUGE FOR STRUCTURAL MEMBERS AND 20-GAUGE FOR ACCESS DOORS AND CABINET PANELS.

2.8 EXTERIOR CORROSION PROTECTION: EXTERIOR CABINET PANELS SHALL BE A BASE COAT OF G-90 GALVANIZED STEEL WITH BOTH EXTERIOR AND INTERIOR SURFACES CLEANED, PHOSPHATIZED AND FINISHED WITH A WEATHER-RESISTANT BAKED ENAMEL FINISH. UNIT'S SURFACE SHALL BE IN COMPLIANCE WITH ASTM B45 SALT SPRAY TESTING AT A MINIMUM OF 672 HOUR DURATION.

2.9 CABINET CONSTRUCTION SHALL PROVIDE HINGED PANELS PROVIDING EASY ACCESS FOR ALL PARTS REQUIRING ROUTINE SERVICE.

2.10 CABINET TOP COVER SHALL BE ONE PIECE CONSTRUCTION OR WHERE SEAMS EXIST, IT SHALL BE DOUBLE-HEMMED AND GASKET-SEALED.

2.11 HINGED ACCESS PANELS: WATER- AND AIR-TIGHT HINGED ACCESS PANELS SHALL PROVIDE ACCESS TO ALL AREAS REQUIRING ROUTINE SERVICE INCLUDING AIR FILTERS, HEATING SECTION, ELECTRICAL AND CONTROL CABINET SECTIONS, OPTIONAL ERV AND POWER EXHAUST FAN SECTION, SUPPLY AIR FAN SECTION, EVAPORATOR AND REHEAT COIL SECTIONS. INSULATED DOORS SHALL BE CONSTRUCTED TO ALLOW THE HINGES TO BE REVERSED IN THE FIELD.

A. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.

B. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

2.12 DRAIN PAN MATERIAL SHALL BE TYPE 430 STAINLESS STEEL DRAIN AND CONSTRUCTED TO SLOPED IN TWO DIRECTIONS TO ENSURE POSITIVE DRAINAGE WITH CORNERS EXPOSED TO STANDING WATER AND DRAIN FITTINGS WELDED LIQUID TIGHT TO PREVENT LEAKS. PAN SHALL HAVE A MINIMUM DEPTH OF 2". BASE OF DRAIN PAN SHALL BE INSULATED WITH 1" THICK FOAM INSULATION.

2.13 PROVIDE OPENINGS EITHER ON SIDE OF UNIT OR THRU THE BASE FOR POWER, CONTROL AND GAS CONNECTIONS.

2.14 CABINET SHALL INCLUDE OPTIONAL INTERIOR LINER CONSTRUCTED OF TYPE 304 STAINLESS STEEL WITH SEALED SEAMS.

2.15 UNIT SHALL BE EQUIPPED WITH A 6" FILTER RACK UPSTREAM OF THE EVAPORATOR. FRAME SHALL BE FIELD-ADJUSTABLE TO MATCH ANY FILTER COMBINATION SPECIFIED IN THE FOLLOWING SECTION.

A. FANS AND MOTORS

2.16 INDOOR FANS SHALL BE HIGH EFFICIENCY BACKWARD CURVED IMPELLER.

2.17 THE INDOOR FAN MOTOR SHALL BE AN ELECTRONIC COMMUTATED MOTOR WITH INTEGRATED POWER ELECTRONICS FOR VARIABLE MOTOR SPEED.

2.18 OUTDOOR FANS SHALL BE DIRECT DRIVE WITH PREMIUM EFFICIENCY MOTORS, STATICALLY AND DYNAMICALLY BALANCED, DRAW THROUGH IN THE VERTICAL DISCHARGE POSITION.

2.19 PROVIDE SHAFTS CONSTRUCTED OF SOLID HOT ROLLED STEEL, GROUND AND POLISHED, WITH KEY-WAY, AND PROTECTIVELY COATED WITH LUBRICATING OIL.

A. AIR FILTERS

2.20 EVAPORATOR INLET SHALL INCLUDE A FULL COMPLIMENT OF PLEATED MEDIA AIR FILTERS. FILTERS SHALL BE:

2.21 2" DEEP MERV 8

A. DAMPERS
   1. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.
   2. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.
   3. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.
   4. Dampers air velocity shall not exceed 2000 fpm.
   5. Return Air damper shall be of same material, construction and leakage rate as outdoor air damper. Return air damper actuator shall be factory mounted and wired sealed spring fully modulating and operate based on outdoor air damper feedback signal to properly regulate RA airflow.
      a. DEHUMIDIFICATION/COOLING

1) Compressors
   (a) All units shall have direct-drive, scroll type compressors.
   (b) Optional Digital Scroll Compressor
   (c) Circuit One
   (d) Circuit One and Circuit Two
   (e) Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
   (f) Internal overloads shall be provided with the scroll compressors.
   (g) Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
   (h) Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
   (i) Provide each unit with <<CIRCUIT_AMOUNT>> hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
   (j) Provide each circuit with automatic reset high and low pressure and high temperature switches for safety control.
2) Coils
   (a) Evaporator, Condenser and Hot Gas Reheat coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
   (b) Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
   (c) The condenser coil shall have a fin designed for ease of cleaning.
   (d) Evaporator coil shall include (six / four) rows of cooling interlaced for superior sensible and latent cooling with a maximum of 12 FPI for ease of cleaning.
   (e) Reheat coil shall be fully integrated into the supply airstream and be capable of delivering design supply air temperature.
   (f) To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated by a minimum of six inches.
   (g) The unit(s) must comply per above - spray coatings not acceptable
   (h) Condenser coil hail guards shall be factory installed.
3) Condenser Section
   (a) Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.
   (b) Fans shall be statically and dynamically balanced.
4) Compressor Capacity Control
   (a) (Mechanical Control: shall be equipped with Refrigerant Capacity Control (RCC) on the lead circuit to modulate compressor capacity during Dehumidification or Cooling modes to maintain evaporator Dehumidification or Cooling setpoint and prevent evaporator frosting or freezing. RCC shall be (standard mechanical / optional electrical). Hot gas by pass shall not be an acceptable compressor capacity control

strategy. The RCC setpoint is factory set, and field adjustable, to maintain desired suction pressure and compressor discharge pressure.

(b) Electronic Control: (Requires Digital Scroll Compressor be selected in compressor section of this specification.) Compressor output capacity shall be controlled by the Main Control Module. (refer to unit control and sequence sections of this specification)

b. HEATING

B. Modulating Indirect Gas Fired Heating System

1. Completely assembled and factory installed heating system shall be located in the primary heating position located downstream of the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors. Threaded gas connection shall terminate at manual shut-off valve. Provide capability for sidewall or thru-base gas piping.
2. Heaters shall include high turn-down burners firing into individual stainless steel tubular heat exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be based on heater gas input capacity 5:1 when =150 MBH or a minimum of 10:1 when >150 MBH.
3. Heater outdoor air inlet shall be hooded and include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet the inlet shall be hooded and shall be located a minimum of 11" beneath the flue outlet. Inlet hood shall include bird screen.
4. Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 430 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.
5. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.
6. Unit controls shall monitor heat output and shall discontinue all heating attempts and or unit operation in the event the heating section fails to ignite or fails to maintain programmed supply air temperature/time.
7. Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.
8. Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.
9. Flame roll-out safeties shall provide continuous monitoring of proper burner operation.
    a. ELECTRICAL RATINGS AND CONNECTIONS

C. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.

D. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

E. Power wiring to be single point connection.

F. Wiring internal to the unit shall be colored and numbered for identification.

G. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

H. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power

I. Unit SCCR rating shall be a minimum of 5kA

J. Optional unit SCCR rating shall be a minimum of 65kA

K. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.
   1. Phase Unbalance Protection: Factory set 2%
   2. Over/Under/Brown Out Voltage Protection: +/-10% of nameplate voltage
   3. Phase Loss/Reversal

L. Factory to mount and wire optional120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

M. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.
   1. UNIT CONTROLS

N. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic. Controller program logic shall include
   1. Include single program with field selectable
      a. Discharge Air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.
      b. Space control with unit conditioning modes enabled and controlled to maintain space setpoints.
         1) Single Zone Variable Air Volume (SZVAV) with unit conditioning modes enabled based on space temperature cooling setpoint and modulate supply fan to maintain setpoint. Cooling will be staged to maintain discharge air cooling setpoint. Heat will modulate to maintain space temperature with indoor fan held at maximum design airflow.

O. MCM shall:
   1. Prevent simultaneous operation of any conditioning modes.
   2. Accept separate setpoints for Occupied and Unoccupied states.
   3. Call for Dehumidification based on dew point setpoints. When no call for Dehumidification is present MCM shall control calls for Cooling, Heating and Economizer modes based on sensible or enthalpy temperature setpoints. MCM shall have onboard clock and scheduling function for occupancy.
   4. Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
   5. Enable HGRH dehumidification and cooling modes and control modulation to maintain (discharge air temperature / space temperature).

6. Unit shall include minimum discharge air control.

P. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished, field installed Discharge Air Temperature.
   1. Space Control or Single Zone VAV: Factory shall furnish Space Temperature and Space Humidity sensor for field installation and connection to the unit
   2. Economizer Option includes Return Air Temperature and Humidity sensor
   3. ERV Option includes exhaust air leaving temperature sensor
   4. Powered Exhaust with Economizer includes duct pressure sensor to be field installed.

Q. System controls shall include:
   1. Anti-cycle timing.
   2. Minimum compressor run/off-times.

R. Optional Smoke Detectors to sense (Return Air / Discharge Air / Return and Discharge Air) stream(s) shall be factory installed and wired.

2.22 POWER EXHAUST – BAROMETRIC RELIEF

A. Provide a factory installed power exhaust assembly that shall be designed to ventilate return air to atmosphere.

B. Plenum mounted direct drive airfoil design exhaust wheel material shall be heavy gauge aluminum, welded construction and rated for up to Class III speed/pressure performance. Belt-drive and/or forward curve plenums fans shall not be used.

C. Exhaust to discharge through gravity dampers located on each side of unit cabinet.
   1. OPTIONAL powered isolation dampers in place of gravity dampers

2.23 OUTDOOR AIR SECTION ENERGY RECOVERY (ERV)

A. The rotor media shall be made of aluminum, formed into a honeycomb structure to minimize pressure loss and avoid plugging. Paper, plastic or fibrous media are not acceptable. The rotor media must be coated to resist corrosion. All surfaces must be coated with a non-migrating desiccant layer to insure that adequate latent capacity is provided. The desiccant coating must be firmly bonded to the aluminum surface and will not be dislodged when challenged with high velocity air up to 5000 feet per minute. Products that lose desiccant when served with high velocity air are not acceptable. The cassette must be a slide out design for serviceability. The media shall be cleanable with low temperature steam, hot water or light detergent without degrading the latent recovery.

B. Sensible and latent recovery efficiencies must be clearly documented through a testing program conducted in accordance with ASHRAE Standard 84 and AHRI 1060. The testing must have been conducted by a qualified independent organization. The performance test reports must be provided for engineering review as part of the submittals for this project.

C. The rotor design shall ensure laminar airflow to minimize parasitic pressure loss and to optimize the operating efficiency of the system fans. The pressure loss across the media shall be no greater than the scheduled pressure loss values. The energy wheel shall operate effectively up to 180 degrees F.

D. The unit shall be provided with a factory set, field adjustable purge sector designed to limit cross contamination to less than .04 percent of that of the exhaust air stream concentration when operated under design conditions. Cross-contamination and performance certification reports shall be provided for engineering review.

E. The rotor media shall be permanent, with an anticipated life of 20 years. It must be tested in accordance with ASTM Standard E-84 and provide smoke and flame spread ratings of less than 25 and 50 as required by NFPA 90A and UL 1995. A copy of the ASTM E-84 test report confirming the method of test and results shall be provided with the submittal. Heat recovery wheels incorporating “throw-away” media and tested to UL900 for Class 2 filters are not acceptable.

F. The wheel manufacturer must have been producing energy recovery wheels for a minimum of ten years.

G. The rotor shall be supplied with perimeter brush seals and face contact seals to minimize air leakage and wheel bypass.

H. The rotor media shall be supported by a structural aluminum hub and aluminum reinforcing spoke system. The rotor bearings must be greaseable and provide L10 life in excess of 20 years.

I. The cassette framework shall be made of galvanized steel to prevent corrosion.

J. The rotor must be driven by long-life polyurethane/polyester composite link belt system. The rotor/cassette shall be designed so that belt can be removed or serviced without the removal of the bearing. A 3 phase A/C gear motor shall be utilized to accommodate variable speed applications.

2.24 ROOF CURB

A. Contractor shall provide factory supplied 14” tall roof curb, 18 gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly.

B. Top of all roof curbs shall be level, with pitch built into curb when deck slopes

C. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

EXECUTION

3.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work and opening dimensions

B. Contractor shall verify that proper power supply adequate to supply the unit.

C. INSTALLATION

1. Contractor shall install in accordance with manufacturer's instructions.
2. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

3.2 MANUFACTURER'S FIELD SERVICES

A. Unit start-up and commissioning shall be completed by a Factory-trained and factory-certified technician.
   1. Manufacturer must have twenty factory-authorized and factory-trained technicians within a 50 mile radius of job site.
   2. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION

SECTION 23 8126.13 - SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air cooled condensing units.

B. Indoor air handling (fan and coil) units for ductless systems.

C. Controls.

1.2 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.

D. Design Data: Indicate refrigerant pipe sizing.

E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.

F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

G. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

H. Project Record Documents: Record actual locations of components and connections.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Filters: One for each unit.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.4 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 INDOOR UNITS FOR DUCTLESS SYSTEMS (SEE DRAWING SCHEDULE FOR PERFORMANCE)

A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
   1. Location: High-wall.
   2. Filter return air with washable, antioxidant pre-filter and a pleated anti-allergy enzyme filter.

B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
   1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
   2. Manufacturer: System manufacturer.

C. Remote Actuators:

2.2 OUTDOOR UNITS (SEE DRAWING SCHEDULE FOR PERFORMANCE)

A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
   1. Comply with AHRI 210/240.
   2. Refrigerant: R-410A.
   3. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23.1 and UL 207.

B. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
   1. Provide thermostatic expansion valves.

C. Operating Controls:
   1. Control by room thermostat to maintain room temperature setting.

D. Mounting Pad: Precast concrete parking bumpers, minimum 4 inches square; minimum of two located under cabinet feet.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.

B. Verify that proper power supply is available and in correct location.

C. Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

A. Install in accordance with NFPA 90A and NFPA 90B.

B. Install refrigeration systems in accordance with ASHRAE Std 15.

C. Pipe drain from indoor unit to nearest floor drain.

END OF SECTION

SECTION 23 8129 - VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Variable refrigerant volume HVAC system includes:
   1. Outdoor/condensing unit(s).
   2. Indoor/evaporator units.
   3. Branch selector units.
   4. Control panels.
   5. Control wiring.

1.2 RELATED REQUIREMENTS

A. Section 22 1005 - Plumbing Piping: Condensate drain piping.

B. Section 23 0800 - Commissioning of HVAC.

C. Section 23 2300 - Refrigerant Piping: Additional requirements for refrigerant piping system.

D. Section 26 0583 - Wiring Connections: Power connections to equipment.

1.3 REFERENCE STANDARDS

A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008, Including All Addenda.

B. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures; Most Recent Edition Cited by Referring Code or Reference Standard.

C. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. ITS (DIR) - Directory of Listed Products; current edition.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Shop Drawings: Installation drawings custom-made for this project; include as-designed HVAC layouts, locations of equipment items, refrigerant piping sizes and locations, condensate piping sizes and locations, remote sensing devices, control components, electrical connections, control wiring connections. Include:
   1. Detailed piping diagrams, with branch balancing devices.
   2. Condensate piping routing, size, and pump connections.
   3. Detailed power wiring diagrams.
   4. Detailed control wiring diagrams.
   5. Locations of required access through fixed construction.
   6. Drawings required by manufacturer.

C. Operating and Maintenance Data:
   1. Manufacturer's complete standard instructions for each unit of equipment and control panel.
   2. Custom-prepared system operation, troubleshooting, and maintenance instructions and recommendations.
   3. Identification of replaceable parts and local source of supply.

D. Project Record Documents: Record the following:
   1. As-installed routing of refrigerant piping and condensate piping.
   2. Locations of access panels.
   3. Locations of control panels.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Company that has been manufacturing variable refrigerant volume heat pump equipment for at least 5 years.

B. Installer Qualifications: Trained and approved by manufacturer of equipment.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.8 WARRANTY

A. Compressors: Provide manufacturer's warranty for six (6) years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced at the discretion of Daikin AC (Americas), Inc. according to Daikin's terms and conditions. All warranty service work shall be preformed by a Daikin factory trained service professional.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Trane-Mitsubishi Heat Recovery - See Drawings Schedules for performance

2.2 HVAC SYSTEM DESIGN

A. System Operation: Heating and cooling, simultaneously.
   1. Zoning: Provide capability for temperature control for each individual indoor/evaporator unit independently of all other units.
   2. Zoning: Provide heating/cooling selection for each individual indoor/evaporator unit independently of all other units.
   3. Provide a complete functional system that achieves the specified performance based on the specified design conditions and that is designed and constructed according to the equipment manufacturer's requirements.
   4. Conditioned spaces are indicated on drawings.
   5. Branch selector unit locations are indicated on drawings.
   6. Required equipment unit capacities are indicated on drawings.
   7. PRELIMINARY Refrigerant piping sizes are shown on the drawings.
      a. CONTRACTOR TO VERIFY PIPE SIZING WITH VENDOR BASED ON FINAL EQUIPMENT LOCATIONS PRIOR TO INSTALLATION
      b. CONTRACTOR TO SUBMIT PIPE SIZING INFORMATION TO DEDC, LLC FOR APPROVAL PRIOR TO INSTALLATION
   8. Connect equipment to condensate piping provided by others; condensate piping is indicated on drawings.

B. Cooling Mode Interior Performance:
   1. Daytime Setpoint: 68 degrees F, plus or minus 2 degrees F.
   2. Setpoint Range: 57 degrees F to 77 degrees F.
   3. Night Setback: 78 degrees F.
   4. Interior Relative Humidity: 20 percent, maximum.

C. Heating Mode Interior Performance:
   1. Daytime Setpoint: 68 degrees F, plus or minus 2 degrees F.
   2. Setpoint Range: 59 degrees F to 80 degrees F.
   3. Night Setback: 60 degrees F.
   4. Interior Relative Humidity: 10 percent, minimum.

D. Outside Air Design Conditions:
   1. Summer Outside Air Design Temperature: 93 degrees F dry-bulb; 75 degrees F wet-bulb.
   2. Summer Outside Air Design Temperature on the Building Roof: 98 degrees F dry-bulb.
   3. Winter Outside Air Design Temperature: 10 degrees F dry-bulb.

E. Energy Design Wind Speed: 25 mph.

F. Refrigerant Piping Lengths: Provide equipment capable of serving system with following piping lengths without any oil traps:
   1. Minimum Piping Length from Outdoor/Central Unit(s) to Furthest Terminal Unit: 540 feet, actual; 620 feet, equivalent.
   2. Total Combined Liquid Line Length: 3280 feet, minimum.
   3. Minimum Piping Length Between Indoor Units: 49 feet.

G. Control Wiring Lengths:
   1. Between Outdoor/Condenser Unit and Indoor/Evaporator Unit: 6,665 feet, minimum.
   2. Between Outdoor/Condenser Unit and Central Controller: 3,330 feet, minimum.
   3. Between Indoor/Evaporator Unit and Remote Controller: 1,665 feet.

H. Controls: Provide the following control interfaces:
   1. For Each Indoor/Evaporator Unit: One wall-mounted wired "local" controller, with temperature sensor; locate where indicated.
   2. One central remote control panel for entire system; locate where indicated.

I. Remote Temperature Sensors: In addition to temperature sensors integral with indoor/evaporator units, provide wall-mounted, wired remote temperature sensors located in the same room for all units.

2.3 EQUIPMENT

A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
   1. Refrigerant: R-410A.
   2. Performance Certification: AHRI Certified; www.ahrinet.org.
   3. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL, listed in ITS (DIR), and bearing the certification label.
   4. Provide outdoor/condensing units capable of serving indoor unit capacity up to 150 percent of the capacity of the outdoor/condensing unit.
   5. Provide units capable of serving the zones indicated.
   6. Energy Efficiency: Report EER and COP based on tests conducted at “full load” in accordance with AHRI 210/240 or alternate test method approved by U.S. Department of Energy.

B. System Controls:
   1. Include self diagnostic, auto-check functions to detect malfunctions and display the type and location.

C. Unit Controls: As required to perform input functions necessary to operate system; provided by manufacturer of units.
   1. Provide interfaces to remote control and building automation systems as specified.
   2. Outside air capability.

D. Refrigerant Piping:
   1. Insulate each refrigerant line individually between the condensing and indoor units.

2.4 VRF OUTDOOR/CONDENSING UNITS

A. Outdoor/Condensing Units: Air-cooled DX refrigeration units, designed specifically for use with indoor/evaporator units; factory assembled and wired with all necessary electronic and refrigerant controls; modular design for ganging multiple units.
   1. Refrigeration Circuit: Scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
   2. Refrigerant: Factory charged.

3. Variable Volume Control: Modulate compressor capacity automatically to maintain constant suction and condensing pressures while varying refrigerant volume to suit heating/cooling loads.
4. Capable of being installed with wiring and piping to the left, right, rear or bottom.
5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle (cooling mode) oil return or defrost is not permitted, due to potential reduction in space temperature.
6. Sound Pressure Level: As specified, measured at 3 feet from front of unit; provide night setback sound control as a standard feature; three selectable sound level steps of 55 dB, 50 dB, and 45 dB, maximum.
7. Power Failure Mode: Automatically restart operation after power failure without loss of programmed settings.
8. Safety Devices: High pressure sensor and switch, low pressure sensor/switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
9. Provide refrigerant sub-cooling to ensure the liquid refrigerant does not flash when supplying to us indoor units.
10. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.
11. Controls: Provide contacts for electrical demand shedding.

B. Unit Cabinet: Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
   1. Designed to allow side-by-side installation with minimum spacing.

C. Fans: One or more direct-drive propeller type, vertical discharge, with multiple speed operation via DC (digitally commutating) inverter.
   1. Provide minimum of 2 fans for each condensing unit.
   2. External Static Pressure: Factory set at 0.12 in WG, minimum.
   3. Indoor Mounted Air-Cooled Units: External static pressure field set at 0.32 in WG, minimum; provide for mounting of field-installed ducts.
   4. Fan Airflow: As indicated for specific equipment.
   5. Fan Motors: Factory installed; permanently lubricated bearings; inherent protection; fan guard; output as indicated for specific equipment.

D. Condenser Coils: Copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.

E. Compressors: Scroll type, hermetically sealed, variable speed inverter-driven and fixed speed in combination to suit total capacity; minimum of one variable speed, inverter driven compressor per condenser unit; minimum of two compressors per condenser unit; capable of controlling capacity within range of 6 percent to 100 percent of total capacity.
   1. Multiple Condenser Modules: Balance total operation hours of compressors by means of duty cycling function, providing for sequential starting of each module at each start/stop cycle, completion of oil return, and completion of defrost, or every 8 hours.
   2. Failure Mode: In the event of compressor failure, operate remaining compressor(s) at proportionally reduced capacity; provide microprocessor and associated controls specifically designed to address this condition.

3. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
4. Provide oil separators and intelligent oil management system.
5. Provide spring mounted vibration isolators.

F. Outdoor Unit shall be capable at the following operating ambient air conditions.
   1. Heat Recovery System
      a. Cooling: 14°F DB to 122°F DB With optional low ambient kit from -4°F DB to 122°F DB
         1) Heating: -13°F WB to 61°F WB
         2) Cooling based synchronous: 14°F DB to 81°F DB
         3) Heating-based synchronous: 14°F WB to 61°F WB

G. Refrigerant Pipe System Design Parameters
   1. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively.
   2. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
   3. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

H. Defrost Operations
   1. The outdoor unit(s) shall be capable of auto defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall be based on outdoor ambient temperatures and outdoor unit heat exchanger temperatures.
      a. Continuous heating defrost
         1) During first two defrost cycles the unit shall allow heating mode indoor unit fans to stay “on” in low speed continuing to heat.
      b. Complete defrost
         1) The third defrost cycle shall switch all outdoor units to defrost mode to fully melt and clear frost, snow or ice accumulations off the outdoor coil while turning “off” heating mode indoor unit fans to maintain efficient performance.

I. Oil Management
   1. The system shall have Hi-POR (High Pressure Oil Return) to ensure a consistent film of oil on all moving compressor parts at low speed. Oil is returned to compressor through a separate oil injection pipe.
      a. Oil return system shall maintain high side pressure return to the compressor
   2. The system shall be provided with a centrifugal oil separator designed to extract oil from the oil/refrigerant gas stream leaving the compressor and return the extracted oil to the compressor oil sump.
   3. The system shall have an oil level sensor in the compressor to provide direct oil level sensing.
   4. The system shall only initiate an oil return cycle if the oil level is too low.
   5. Timed oil return operations or non-oil level sensing systems shall not be permitted.

J. Cabinet
   1. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with an enamel finish.
   2. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.

3. The front panels of the outdoor units shall be removable type for access to internal components.
4. A smaller service access panel, not larger than 6.25"x 6.67" and secured by a maximum of (2) screws shall be provided to access the following:
    a. Service tool connection
    b. DIP switches
    c. Auto addressing
    d. Error codes
5. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front or through the bottom of the unit.

K. Sound Levels
1. Each cabinet shall be rated with a sound level not to exceed 59.5 dB(A) when tested in an anechoic chamber under ISO3745 standard.

L. Sensors
1. Each single cabinet shall have
    a. Suction temperature sensor
    b. Discharge temperature sensor
    c. High Pressure sensor
    d. Low Pressure sensor
    e. Outdoor temperature sensor
    f. Outdoor unit heat exchanger temperature sensor

2.5 BRANCH CONTROLLER

A. General
1. Branck Controller unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
2. Unit casing shall be made with galvanized steel.
3. Unit shall require 208-230V/1-phase/60Hz power supply.
4. Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems simultaneous cooling and heating operation.
5. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.

2.6 INDOOR/EVAPORATOR UNITS

A. All Indoor/Evaporator Units: Factory assembled and tested DX fan-coil units, with electronic proportional expansion valve, control circuit board, factory wiring and piping, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
1. Refrigerant: Refrigerant circuits factory-charged with dehydrated air, for field charging.
2. Temperature Control Mechanism: Return air thermistor and computerized Proportional-Integral-Derivative (PID) control of superheat.
3. Coils: Direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
    a. Provide thermistor on liquid and gas lines.
4. Fans: Direct-drive, with statically and dynamically balanced impellers; high and low speeds unless otherwise indicated; motor thermally protected.

5. Return Air Filter: Washable long-life net filter with mildew proof resin, unless otherwise indicated.
6. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.
    a. Units With Built-In Condensate Pumps: Provide condensate safety shutoff and alarm.
    b. Units Without Built-In Condensate Pump: Provide built-in condensate float switch and wiring connections.
7. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.

B. Wall Mounted - Standard
    1. General
        a. Unit shall be factory assembled, wired, piped and run tested.
        b. Unit shall be designed to be installed for indoor application.
        c. Unit shall be attached to an installation plate/bracket that secures unit to the wall.
        d. The depth of the unit shall not exceed 10-1/2 inches.
    2. Casing/Panel
        a. Unit case shall be manufactured of heavy duty Acrylonitrile Butadiene Styrene (ABS) and High Impact Polystyrene (HIPS) plastic.
        b. Unit case shall have a pearl white finish.
        c. The front surface of the unit shall have an architectural curved panel with pearl white finish.
    3. Cabinet Assembly
        a. Unit shall have one supply air outlet and one return air inlet.
        b. Unit shall be equipped with factory installed temperature thermistors for
            1) Return air
            2) Refrigerant entering coil
            3) Refrigerant leaving coil
        c. Unit shall have a built-in control panel to communicate with the outdoor unit.
        d. Unit shall have the following functions as standard
            1) Self-diagnostic function
            2) Auto restart function
            3) Auto changeover function
            4) Auto clean function
            5) Dehumidifying function
            6) Hot Start
            7) Sleep mode
        e. Unit shall be capable of refrigerant piping in 4 different directions.
        f. Unit shall be capable of drain piping in 2 different directions.
    4. Fan Assembly
        a. The unit shall have a direct drive, cross flow fan made of high strength ABS plastic.
        b. The fan motor is Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
        c. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
        d. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
        e. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Power Cool, and Auto.
        f. In heating mode, the indoor fan shall have the following settings: Low, Med, High, Power Heat, and Auto.
        g. The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.

h. (viii) Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.
i. Unit shall have factory installed motorized guide vane to control the direction of flow of air from side to side.

5. Filter Assembly
   a. The return air inlet shall have a factory supplied primary removable, washable filter.
   b. The filter access shall be from the front of the unit.
6. Coil Assembly
   a. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
   b. Unit shall have minimum of 2 rows of coils.
   c. Unit shall have a factory supplied condensate drain pan below the coil.
   d. Unit shall be designed for gravity drain.
   e. Unit shall have a factory insulated drain hose to handle condensate.
   f. Unit shall have provision of 45° flare refrigerant pipe connections
   g. The coil shall be factory pressure tested at a minimum of 551 psig.
   h. (viii) All refrigerant piping from outdoor unit to indoor unit shall be field insulated.
7. Condensate Sensor Connection
   a. The unit shall include a factory installed condensate sensor connection compatible with the AquaGuard® AG-9300-LG condensate sensor.
8. Microprocessor Control
   a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
   b. The unit shall be able to communicate with the outdoor unit using a field supplied minimum of 18 AWG, 4 core, stranded and shielded power/communication cable.
   c. The unit shall be capable of setting Cooling Only operation.
   d. The unit controls shall operate the indoor unit using one of the five operating modes:
      1) Auto changeover
      2) Heating
      3) Cooling
      4) Dry
      5) Fan only
9. Electrical
   a. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz)
   b. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.
10. Controls
    a. The indoor unit shall be supplied with a wireless handheld controller.
    b. An optional wired controller shall be available as an additional accessory.

C. Ceiling Cassette
   1. General
      a. Unit shall be factory assembled, wired, piped and run tested.
      b. Unit shall be designed to be installed for indoor application.
      c. Unit shall be designed to mount recessed in the ceiling and has a surface mounted concentric grille on the bottom of the unit.
   2. Casing/Panel
      a. Unit case shall be manufactured using galvanized steel plate.

b. The unit shall be provided with an off-white Acrylonitrile Butadiene Styrene (ABS) polymeric resin architectural grille.
c. The grille shall have a tapered trim edge, and a hinged, spring clip (screw-less) return air filter-grille door.
d. Unit shall be provided with metal ears designed to support the unit weight on four corners.
e. Ears shall have pre-punched holes designed to accept field supplied all thread rod hangers.

3. Cabinet Assembly
   a. Unit shall have four supply air outlets and one return air inlet.
   b. The supply air outlet shall be through four-directional slot diffusers each equipped with independent oscillating motorized guide vane designed to change the airflow direction.
   c. The grille shall have a discharge range of motion of 40° in an up/down direction with capabilities of locking the vanes.
   d. The unit shall have a guide vane algorithm designed to sequentially change the predominant discharge airflow direction in counterclockwise pattern.
   e. Guide vanes shall provide airflow in all directions.
   f. Unit shall be equipped with factory installed temperature thermistors for
      1) Return air
      2) Refrigerant entering coil
      3) Refrigerant leaving coil
   g. Unit shall have a built-in control panel to communicate with the outdoor unit.
   h. (viii) The unit shall have provision for fresh air ventilation through a knock-out on the cabinet.
   i. The unit shall have factory designated branch duct knockouts on the unit case.
      1) The branch duct knockouts shall have the ability to duct up to half of the unit airflow capacity.
      2) The branch duct shall be ducted within the same room as the indoor unit.
   j. Unit shall have the following functions as standard
      1) Self-diagnostic function
      2) Auto restart function
      3) Auto changeover function
      4) Dehumidifying function
      5) Forced operation
      6) Hot Start
      7) Sleep mode
4. Fan Assembly
   a. The unit shall have a single direct driven turbo fan.
   b. The fan motor is Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
   c. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
   d. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
   e. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Power Cool, and Auto.
   f. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
   g. (viii) The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.
   h. Unit shall have factory installed motorized louvers to provide flow of air in up and down direction for uniform airflow.
5. Filter Assembly

a. The return air inlet shall have a factory supplied primary removable, washable filter.
b. The filter access shall be from the bottom of the unit.

6. Coil Assembly
   a. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
   b. Unit shall have minimum of 2 rows of coils.
   c. Unit shall have a factory supplied condensate drain pan below the coil.
   d. Unit shall have an installed and wired condensate drain pump capable of providing minimum 31.5 inch lift from bottom surface of the unit.
   e. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
   f. Unit shall have provision of 45° flare refrigerant pipe connections.
   g. The coil shall be factory pressure tested at a minimum of 551 psig.
   h. (viii) All refrigerant piping from outdoor unit to indoor unit shall be field insulated.
7. Microprocessor Control
   a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
   b. The unit shall be able to communicate with the outdoor unit using a field supplied minimum of 18 AWG, 4 core, stranded and shielded power/communication cable.
   c. The unit controls shall operate the indoor unit using one of the five operating modes:
      1) Auto changeover
      2) Heating
      3) Cooling
      4) Dry
      5) Fan only
8. Electrical
   a. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz)
   b. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.
9. Controls
   a. The indoor unit shall be supplied with a wireless handheld controller.
   b. An optional wired controller shall be available as an additional accessory.

D. Recessed Ceiling Units Four-way airflow cassette with central return air grille, sized for installation in standard 24 by 24 inch lay-in ceiling grid.
   1. Cabinet Height: Maximum of 12 inches above face of ceiling.
   2. Exposed Housing: White, impact resistant, with washable decoration panel.
   3. Maintenance Access: All electrical components accessible through decoration panel.
   4. Supply Airflow Adjustment:
      a. Via motorized louvers which can be horizontally and vertically adjusted from 0 to 90 degrees.
      b. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
   5. Sound Pressure: Measured at low speed at 5 feet below unit.
   6. Fan: Direct-drive turbo type.
   7. Condensate Pump: Built-in, with lift of 21 inches, minimum.
   8. Provide side-mounted supply air branch duct connection.
   9. Provide side-mounted fresh air intake duct connection.

E. Wall Surface-Mounted Units: Finished white casing, with removable front grille; foamed polystyrene and polyethylene sound insulation; wall mounting plate; polystyrene condensate drain pan.
   1. Airflow Control: Auto-swing louver that closes automatically when unit stops; five (5) steps of discharge angle, set using remote controller; upon restart, discharge angle defaulting to same angle as previous operation.
   2. Sound Pressure Range: Measured at low speed at 3.3 feet below and away from unit.
   3. Condensate Drain Connection: Back, with piping concealed in wall.
   4. Fan: Direct-drive cross-flow type.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.

B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.

C. Notify DEDC, LLC if conditions for installation are unsatisfactory.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install refrigerant piping in accordance with equipment manufacturer's instructions.

C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).

D. Coordinate with installers of systems and equipment connecting to this system.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Provide manufacturer's field representative to inspect installation prior to startup.

3.4 SYSTEM STARTUP

A. Provide manufacturer's field representative to perform system startup.

B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.

C. Adjust equipment for proper operation within manufacturer's published tolerances.

3.5 CLEANING

A. Clean exposed components of dirt, finger marks, and other disfigurements.

3.6 CLOSEOUT ACTIVITIES

A. Demonstration: Demonstrate operation of system to Owner's personnel.
   1. Use operation and maintenance data as reference during demonstration.
   2. Conduct walking tour of project.
   3. Briefly describe function, operation, and maintenance of each component.

B. Training: Train Owner's personnel on operation and maintenance of system.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of two hours of training.
   3. Instructor: Manufacturer's training personnel.
   4. Location: At project site.

3.7 PROTECTION

A. Protect installed components from subsequent construction operations.

B. Replace exposed components broken or otherwise damaged beyond repair.

3.8 MAINTENANCE

A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

END OF SECTION

SECTION 23 8200 - CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electric unit heaters.

1.2 RELATED REQUIREMENTS

A. Section 23 0513 - Common Motor Requirements for HVAC Equipment.

B. Section 23 0716 - HVAC Equipment Insulation.

C. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections. Installation of room thermostats. Electrical supply to units.

1.3 REFERENCE STANDARDS

A. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide typical catalog of information including arrangements.

C. Shop Drawings:
1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.

D. Manufacturer's Instructions: Indicate installation instructions and recommendations.

E. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.

F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

G. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 ELECTRIC UNIT HEATERS

A. Manufacturers: See Mechanical Drawings for schedules

B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.

C. Assembly: Suitable for mounting from ceiling or structure above with built-in controls, thermal safety cut-out, and electric terminal box.

D. Housing:
   1. Horizontal Projection Units:
      a. Construction materials to consist of heavy gage steel with galvanized, polyester powder coat, or high gloss baked enamel finish.
      b. Provide with threaded holes for threaded rod suspension.
      c. Provisions for access to internal components for maintenance, adjustments, and repair.
   2. Vertical Projection Units:
      a. Construction materials to consist of heavy gage steel with polyester powder coat or high gloss baked enamel.
      b. Provide with mounting support brackets or provisions for mounting from ceiling or structure above.
      c. Provisions for access to internal components for maintenance, adjustments, and repair.

E. Controls:
   1. Fan speed switch.
   2. Built-in thermostat.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are suitable for installation.

3.2 INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. Unit Heaters:
   1. Hang from building structure, with pipe hangers anchored to building, not from piping or electrical conduit.
   2. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

C. Units with Electric Heating Elements:
   1. Install as indicated including electrical devices furnished by manufacturer but not factory installed.

2. Install wiring in accordance with the manufacturer's wiring diagram submittal and Section 26 0583.

END OF SECTION

SECTION 23 8210 - GAS-FIRED INFRARED UNIT HEATERS

PART 1 GENERAL

1.1 CODES AND STANDARDS

A. American National Standard / CSA Standard Gas-Fired Low Intensity Infrared Heaters: Construct and certify gas-fired infrared heaters in accordance with latest edition ANSI Z83.20 / CSA 2.34 "Gas-Fired Low-Intensity Infrared Heaters" including all current supplements.

B. Installation Compliance: United States: Refer to National Fuel Gas Code NFPA 54/ANSI Z223.1 - latest revision. Canada: Refer to Natural Gas and Propane Installation Code CSA B149.1 - latest revision.

C. CSA Compliance: Provide CSA Seal affixed to each burner name plate and provide CSA Certification of heater design as vented or unvented infrared heater for indoor installation.

D. National Standard Gas Piping Compliance: Install and connect gas piping to gas fired infrared heaters in accordance with United States: Refer to National Fuel Gas Code NFPA 54/ANSI Z223.1 - latest revision. Canada: Refer to Natural Gas and Propane Installation Code CSA B149.1 - latest revision.

E. National Electrical Code Compliance: Install and connect electrical wiring to gas fired infrared heaters in accordance with: 1.) United States: Refer to National Electrical Code®, NFPA 70 - latest revision. Wiring must conform to the most current National Electrical Code®, local ordinances and any special diagrams furnished. 2.) Canada: Refer to Canadian Electrical Code, CSA C22.1 Part 1 - latest revision.

F. National Performance Rating for Gas Fired Infrared Heaters Standard: Radiant output of gas fired infrared heaters shall be rated in accordance with AHRI Standard 1330. Refer to Performance Rating for Radiant Output of Gas Fired Infrared Heaters Standard CAN/ANSI/AHRI 1330-2015.

1.2 WARRANTY

A. Provide written warranty, by manufacturer, agreeing to replace/repair, within warranty period, components of gas fired infrared systems furnished by manufacturer, which are defective in either material or workmanship, provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty periods follows:

B. Three (3) year warranty on the burner system from the date of final acceptance of the infrared heaters

1.3 QUALITY ASSURANCE

A. Approved Manufacturers
   1. Infrared heating system shall be COMPACT™ BH radiant heaters as manufactured by Roberts Gordon LLC., Buffalo, New York.

B. Manufacturer's Qualifications
   1. Firms regularly engaged in manufacture of gas fired radiant systems with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 15 years.

C. Alternate Manufacturers
   1. Other low intensity infrared heaters (of equal or greater thermal efficiency) (of an Infrared Factory (IF) as high as 15 when tested in accordance to AHRI standard 1330 for Radiant Output of Gas Fired Infrared Heaters,) and with the same or lower burner firing rate capacity, and with the infrared distribution pattern shown on drawing may be acceptable provided they meet the intent of these specifications and prior approval in writing is obtained from the engineer at least twenty (20) days before the bid date. If such systems are approved, the contractor assumes responsibility for the design, performance and expense of same. The redesigned system, gas piping, and electric wiring shall be done by a registered mechanical engineer. Shop drawings of the entire new system shall be provided by this contractor. The contractor should state the amount to be credited to the owner due to this substitution.
      a. Where approved substitutes are used, the contractor assumes all responsibility for physical dimensions and all other resulting changes. This responsibility extends to cover all extra work as necessitated by other trades as a result of the substitutions.
      b. The engineer reserves the right to require the contractor to remove and replace any material or equipment which does not meet specifications or does not have any prior approval as a substitute item. Work shall be completed immediately without cost or inconvenience to the owner.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Burner Box
   1. (Natural Gas) (Propane) model, nickel plated steel burner cup, outside air adapter, direct spark ignition, three try ignition module, all components easily accessed, durable spot welded construction, mica flame observation window, balanced air rotor, gas and electric controls are separated from the combustion air stream, stainless steel flexible gas line and high-pressure gas cock assembly included, for U.S. models only.
   2. Heater shall be equipped with permanently lubricated combustion blower with thermal overload protection.

B. Burner Controls
   1. Factory Wired: All burners shall be factory wired for 120 volts AC with transformer for 24 volts AC DSI operation and supplied with a grounded three wire pigtail located at rear of burner.
   2. Fail-Safe Controls: To assure a high degree of fail-safe operation, the design shall include an air proving safety pressure switch to verify blower operation before gas valve opens. In the event of a power failure the gas valve in burners close in safe position.
   3. 3. Ignition Controls: All gas firing burner units shall be equipped with a Direct Spark Ignition Module (DSI) fully automatic. The DSI module shall have a 15-second flame response time per ignition trial before lockout occurs. In addition, the DSI module shall be capable of a minimum of 3 trials for ignition to provide maximum reliability.

C. Reflectors - High Efficiency
   1. Provide high radiant reflective (aluminum) (stainless steel) reflectors installed over all heat exchanger tube. Provide wide parabolic design reflector with 12 reflective surfaces and additional

ribbing formed into reflector sides for added rigidity. Reflector shall be capable of producing an Infrared Factor (IF) as high as 15 when tested in accordance to AHRI standard 1330 for Radiant Output of Gas Fired Infrared Heaters. Reflector shall reflect 100% of the infrared energy that it receives from the heat exchanger tube directly to the floor. Reflectors with less than 12 reflective surfaces shall not be allowed. In order to maximize radiant output and reduce convective heat losses, reflectors are to extend below the bottom of the heat exchanger tube. Provide continuous reflector over all tube and fitting heat exchanger surfaces. Provide reflector end caps as necessary to reduce convective heat losses.

D. C. Reflectors - Standard
   1. Provide high radiant reflective (aluminum) (stainless steel) reflectors installed over all heat exchangers. Provide reflector joint pieces over heat exchanger fittings such as elbows so reflector covers heat exchanger continuously. In order to maximize radiant output and reduce convective heat losses, reflectors are to extend below the bottom of the heat exchanger tube.
   2. 1. Over all fittings: All reflectors at termination of the heat exchanger pipe and any elbows shall have end caps to prevent convective heat from escaping.
   3. 2. Side Reflectors: System to have (aluminum) (stainless steel) perimeter side extension reflector in certain areas of layout as shown on plan where specified. Side reflectors permanently attach to side to top reflector and are secured to the pipe by side reflector supports and two "Z" clips for each 8’ (2.44 m) section of side reflector. To prevent convection losses, tilting of reflectors will not be acceptable.

E. Thermostats
   1. Provide where indicated Mount thermostat 5 ft. - 6 ft. (1.5 - 2 m) above finish floor or otherwise as noted on the drawing.

F. Radiant Piping - Heat Exchanger
   1. 1. Radiant Tube: Shall be new 4 in. (10 cm) O.D. (Heat Treated Aluminized) (Hot-Rolled) steel tube X 16 gauge wall with an emissivity factor of 0.80 or greater. ALUMITHERM® steel (aluminized steel/titanium alloy) tubing will be supplied on the first 10 ft. of each radiant heater.
   2. 2. Fittings: Shall be 4 in. (10 cm) O.D. Aluminized steel X 16 gauge wall. Tubes shall be as described in the installation, operation and service manual.
   3. 3. Hanging Materials: All system’s tube must be supported in accordance with acceptable practices, local codes, seismic requirements, and applicable standards and as shown on plans. Heat exchanger tube shall pitch down at least .5 in. per 20’ (1.27 cm per 6.1 m) away from burner box.

PART 3 INSTALLATION

3.1 INSTALLATION OF GAS FIRED RADIANT HEATERS

A. General
   1. Install gas fired infrared heaters as indicated, in accordance with manufacturer's installation operation and service manual and in compliance with applicable codes and approvals. Allow adequate space for servicing or removal of the unit without disturbing other piping or equipment.

B. Support

1. Suspend heat exchanger, burner, gas piping, conduit, and reflectors from building substrate as indicated, or if not indicated, in manner to provide durable and safe installation; and in accordance with manufacturer's installation operation and service manual. Mounting height to be a minimum feet (_____ m) from floor level.

C. Clearance to Combustibles
1. Always maintain clearance to combustibles as outlined and printed on burner nameplate and in manufacturer's product data. Measure clearance distance from surface of heat exchanger or as indicated by approval agency's listing.

D. Venting
1. Install vent piping as indicated on plans and as required by the manufacturer. Terminate where indicated on the drawings with a vent terminal assembly as supplied by the manufacturer. The venting must be installed in accordance with the requirements within the installation operation and service manual and the following codes: United States: Refer to National Fuel Gas Code NFPA 54/ANSI Z223.1 - latest revision.

E. Gas Piping
Install gas piping as indicated and in accordance and in compliance with applicable codes and approval: United States: Refer to National Fuel Gas Code NFPA 54/ANSI Z223.1 - latest revision. Canada: Refer to Natural Gas and Propane Installation Code CSA B149.1 - latest revision.
1. Required Gas Supply Inlet Pressures:
Natural Gas
40,000-150,000 Btu/h 4.6” wc Min 14” wc Max
2. Local Codes: Gas supply piping must meet local requirements and be sized in accordance with Btu/h demand, available pressure and total length of supply line required for the installation. Connection from supply line to burner unit must be made in accordance with installation operation and service manual. Gas shut-off cock, as supplied with unit, and controls in unit must not be subjected to more than 1/2 lb. or 14” wc pressure.
3. Drip Legs: Provide drip legs at all gas risers.

F. Electrical Wiring
1. Install electrical wiring as indicated. Connect power wiring to burners and control wiring between burners and thermostats in accordance with manufacturer's wiring diagrams.

G. Thermostats
1. Mount thermostats 5 ft. - 6 ft. above finished floor, if not otherwise indicated.

H. Thermostat Guards
1. All thermostats to be covered with a locking thermostat cover.

3.2 FIELD QUALITY CONTROL

A. Start-Up
1. Start-up, test, and adjust gas fired infrared heaters in accordance with manufacturer's start-up instructions in the installation operation and service manual, and Utility Company's requirements.

Check and calibrate controls, adjust burners if applicable according to manufacturer's installation operation and service manual instructions for maximum efficiency.

3.3 CLOSEOUT PROCEDURES

A. Training
   1. Provide services of manufacturer's technical representative to instruct operating personnel in operation and maintenance of gas fired radiant heaters.
   2. Schedule instruction with operating building owner, provide at least 7 days notice.

END OF SECTION

SECTION 25 0500 - COMMON WORK RESULTS FOR INTEGRATED AUTOMATION

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

A. Section 23 0911 Direct-Digital Control System for HVAC

B. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.

C. Section 25 1400 - Integrated Automation Local Control Units.

D. Section 26 0553 - Identification for Electrical Systems.

1.2 DEFINITIONS

A. This article includes typical definitions used and applied throughout Division 25.

B. Cloud: Virtual private or rented server data hosting service.

C. FDD: Fault detection and diagnostics.

D. ECM: Energy conservation measure.

E. GUI: Graphical user interface.

F. HMI: Human machine interface or operator interface.

G. I-O: Input and output objects or points or field-interfaced devices.

H. IT: Information Technology or Computer-Network Agent.

I. OEM: Original equipment manufacturer or factory-provided.

J. O&M: Operations and maintenance.

K. Peer-to-Peer: Resource linking and sharing between two or more devices.

L. Point-to-Point: Device to device or system to device interconnectivity reference.

M. RO: Read-only access to controller and system.

N. RW: Read and write access to controller and system.

O. Virtual: Software-coordinated.

P. Integrated Automation Nomenclatures:
   1. ATC: Automated temperature controls.
   2. BAS: Building automation system or integrated automation for buildings.

3. BMS: Building management system or integrated automation for buildings.
4. DCS: Distributed control system.
5. EIS: Energy information system or EMS with built-in data analytical tools.
6. EMS: Energy management system.
7. FMS: Facility management system or enterprise integrated automation.
8. UMS: Utility Monitoring and Control System.

Q. Operator Interface Nomenclatures:
1. AWS: Advanced workstation or administrator workstation.
2. EWS: Engineer's workstation or management workstation.
3. HMI Screen: OD or operator display or user interface (UI).
4. OD: Operator display or HMI panel screen or graphic terminal.
5. OWS: Operator's workstation or supervisory workstation.
6. SCADA: Supervisory control and data acquisition.
7. Terminal Device: Same as OD or HMI.
8. User Interface (UI): Same as OD, HMI screen or terminal device.

R. Controllers or Local Control Units (LCU's) Nomenclatures:
1. AAC: Advanced application controller or programmable controller.
2. ASC: Application specific controller or pre-programmed controller.
3. BC: Building controller or network supervisory controller.
4. DDC: Distributed digital controller or direct digital controller.
5. NC: Network supervisory controller or building controller.
6. OEM: Original equipment manufacturer controller.
7. PAC: Programmable automation controller.
8. PLC: Programmable logical controller.
9. RTU: Remote terminal unit or small DDC, ASC, SA or SS.
10. SA: Smart actuator or network-connected actuated device.
11. Smart I/O or I/O: Remote input-output device.
12. SS: Smart sensor or network-connected sensor.

S. Communication Nomenclatures:
1. BBMD: Broadcast management device.
2. GEN: General.
3. GW: Gateway.
4. Protocol: Communications language, default to BACnet MS/TP for field devices and BACnet/IP for supervisory devices unless otherwise indicated per ASHRAE Std 135
5. RTR: Router.

1.3 REFERENCE STANDARDS

A. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2016.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Product Interconnectivity Coordination:
   1. Furnish Division 23-specified equipment such as chillers, boilers, air handling units, refrigeration systems, air compressors and others with their respective controls as indicated in their respective sections ensuring full Division 25 compatibility in terms of direct or integrated interconnectivity.

B. Obtain and comply with existing Owner controls standards unless specified.

C. Obtain and comply with existing Owner Information Technology standards and procedures to install new equipment, devices, and networks unless specified.

1.5 SUBMITTALS

A. IT Submittal: Submit detailed network riser drawings to Owner's IT division for review.

B. Submittal Package:
   1. Title sheet.
   2. Detail Drawings:
      a. Proposed LCU per Section 25 1400 requirements.
      b. Typical I-O device terminations along with wire, and cable schedules.
      c. Typical panel-mounted or junction box-mounted products.
      d. Typical network terminations along with wire, cable, and fiber schedules.
   3. Network Riser Drawings:
      a. Detailed single line diagram that shows:
         1) Operator interfaces, controllers, and networking components.
         2) Location Reference: List specific building room where intended device is to be physically present.
         3) Address Reference: Proposed IP or subnet-instance address per device. Show common subnet mask and gateway addresses with firewall specifics on each sheet.
         4) Bill of Materials: List all installed products including software pieces.
      b. Graphic panel samples of HMI network riser interface if different than main diagrams.
      c. HMI Navigation Scheme: Provide a sketch showing smaller graphic panel samples arranged to depict proposed system navigation specifics.
   4. System or Equipment Drawings:
      a. System and equipment schematic diagrams.
      b. I-O Riser Schematics: Show controller connectivity diagrams as well as controller schedule references for typical work such as packaged equipment and terminal units.
      c. Panel Diagrams: Include sub-panels, terminal devices per Section 25 3500 and complete bill of materials.
      d. I-O Schedules: Include bill of materials and sequence of operations.
      e. Graphic Panels: Proposed samples.
   5. Integrated Device Drawings: Apply 'System or Equipment Drawings' format and include object (point) reference tables.

6. Product Data: Provide red-marked product data sheets for each furnished item with associated components and accessories.

C. Closeout or As-Build: Update all approved submittal packages to reflect specifics and include:
   1. Software Schedules: List all installed software pieces including controller codes and include a soft-copy of each for Owner use.
   2. References:
      a. Calibration Certificates: Factory or field generated as applicable.
      b. Construction Administration: Red-mark submittal drawings to show issued reference numbers for issued documents such as requests for information and field directives.
      c. Electrical: Red-mark scope-related construction drawings to show installed raceway, cable, wire, and tubing.
   3. O&M Data: List of all components with part numbers, sources of supply, and operation and maintenance instructions.
   4. Warranty letter.

1.6 QUALITY ASSURANCE

A. Provide products of the latest technology available unless specified.

B. Provide products listed, classified, and labeled for intended purpose.

1.7 DELIVERY STORAGE AND HANDLING

A. Store products in their unopened manufacturer's packaging until ready for installation at on-site work area, project designated storage area or off-site storage.

1.8 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

B. Type: Provide a full warranty applicable to all Division 25 for a period of one-year after warranty letter acceptance.
   1. Warranty Letter:
      a. Notify: Submit draft for Owner review after substantial job completion.
      b. Acceptance: Receipt of signed-off copy or completion of listed punch-list items.
   2. Products: Repair or replace due to defect or malfunction.
   3. Interface: Repair or replace product interface such as wiring, cables, tubing, and related interconnecting media due to defect or malfunction.
   4. Software:
      a. Controller-end: Debug and correct defect or malfunction.
      b. Computer-end or Server-end: Apply manufacturer patch, update or replacement as required to correct defect, malfunction or security flaw.
      c. Add-on Products: Replace with next available version after three consecutive issues such as defect, malfunction or security flaw.

PART 2 PRODUCTS

2.1 **CONTROL SYSTEM TO BE SIEMENS CONNECTED TO OWNER'S OFF-SITE SIEMENS CENTRAL BUILDING MONITORING SYSTEM**

PART 3 EXECUTION

3.1 INSTALLATION

A. Raceways, Cable and Wires: Install per NECA 1 following project proposed or pre-defined routes. Field verify and ensure that installed items will not inhibit access to any device or limit service clearances of nearby equipment.

B. Terminations: Leave a minimum of 4 inch of loop per cable or wire end to ease future servicing needs. Accommodate excess neatly turned into a loop inside junction box, device access box or control panel wire duct as applicable.

C. Panel-mounted Items: Install per NECA 1 and leave a minimum sub-panel blank space capacity of 20 percent. Cap any unused panel box penetrations.

D. Identification: Identify and tag installed components as follows:
   1. Panels:
      a. Door: Fasten a 1-1/4 inch blue nameplate tag with 1 inch white characters.
      b. Sub-panel Items: Apply a 1/2 inch adhesive tag suitable for damp harsh environment with 1/4 inch black characters per item. Identify and tag remote electrical panel/breaker panel feed and remote data closet with switch port as well.
   2. Raceway, Cable and Wires: Comply with Section 26 0553. Tag each cable or conductor with both hardware and software tags when different. Include the power supply voltage only on the conductors powering the end device. Label hardwired interlocks as "Safety Interlocks".
   3. Other devices: Comply with Section 23 0553 requirements.

E. Passive Sensors Signal Adjustment: Measure and add sensor wiring resistance to controller input definition settings to ensure accurate temperature readings.

F. Control Schematics: Provide wall-fastened laminated copy of related drawings such as schematics, wiring diagrams, schedules, and sequences of operation per system or equipment.

3.2 FIELD QUALITY CONTROL

A. Verify that products were installed per manufacturer instructions.

B. Verify that all furnished only products were installed by others per respective manufacturer instructions.

C. TAB Support: Provide a minimum of two (2) resources to assist with test requirements specified in Section 23 0593 for one week.

D. Field Verifications:

1. Test LCU to I-O wiring and verify field raceway and cable tags.
2. Test LCU programming and apply cable resistance differences to passive devices.
3. Test LCU controllability and tune loops until attaining specified performance.
4. Test HMI to LCU connectivity wiring links and verify raceway and cable tags.
5. Test LCU-related HMI configuration such as panels, interface navigation, and alarms.
6. Test LCU-related HMI schedules, data logging setup and report generation features.
7. Completion: Mark LCU-related submittal sheets, schedules, and graphic panels upon completion of listed field verifications and include with submittals.

3.3 CLEANING

A. Execute housekeeping measures by keeping work areas neat, clean all the time.

B. Recycle or dispose discarded packaging, materials, and pieces as per contract guidelines.

3.4 CLOSEOUT ACTIVITIES

A. Demonstration: Demonstrate operation of system to Owner's personnel.
   1. Use operation and maintenance data as reference during demonstration.
   2. Briefly describe function, operation, and maintenance of each component.

B. Training: Train Owner's personnel on operation and maintenance of system.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of two hours of training.
   3. Location: At project site.
   4. Report: Documented list of attendees, provide tests and issue attendance certificates.

3.5 MAINTENANCE

A. O&M Service: Provide as an add-on item to the base bid proposal to include 12 full day visits by a technician and helper to execute non-warranty work which includes:
   1. Modifications: Adding, modifying or deleting points, elements, devices, and features such as trends, graphs, graphic panels, and data backups.

END OF SECTION

SECTION 25 1400 - INTEGRATED AUTOMATION LOCAL CONTROL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Advanced application (programmable) controllers (AAC).

B. Original equipment manufacturer (OEM) controllers.

1.2 RELATED REQUIREMENTS

A. Section 25 0500 - Common Work Results for Integrated Automation.

1.3 REFERENCE STANDARDS

A. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

B. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2016.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. See Section 25 0500 for submittal requirements. Unless otherwise indicated, submittals may be arranged according to individual sections and submitted separately or combined into comprehensive package covering work of this division.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Siemens Industry, Inc; _____: www.siemens.com/#sle.

Control system to be Siemens connected to Owner's off-site Siemens central building monitoring system

2.2 ADVANCED APPLICATION (PROGRAMMABLE) CONTROLLERS

A. Inputs: 10-binary and 12-analog (configurable).

B. Outputs: 8-binary (6-configurable) and 8-analog (configurable).

C. I-O Spare Capacity: Include a 20 percent object (point) allowance for incidentals.

D. Wire Connections: Device to feature removable wire terminals.

E. Memory: 32 Mb non-volatile battery-backed with a 32-bit memory bus.

F. Communications Protocol: BACnet MS/TP per ASHRAE Std 135.

G. Certification: BACnet Testing Laboratory (BTL) certified device listed under the BACnet Advanced Application Controller (B-AAC) device profile in compliance with ASHRAE Std 135.

H. Accessories: Transformers, on-off switch, relays, transducers, vinyl-metallic adhesive identification tags, and programing software.

I. Mounting:

2.3 ORIGINAL EQUIPMENT MANUFACTURER (OEM) CONTROLLERS

A. Requirement: Connect OEM (factory-installed) controllers such as variable frequency drivers (VFD's), variable speed drives (VSD's), HVAC equipment including terminal units, plumbing, and fire protection equipment.

B. Gateway: Provide external data exchange interface of the device-poll type for products with different communications protocol than BACnet IP per ASHRAE Std 135.

PART 3 EXECUTION

3.1 INSTALLATION

A. Controls contractor to provide Siemens HVAC controls, per design drawings, integrated with Owner's Siemens controls system. All control points, alarms, schedules, etc. to be relayed to/from Owner's central (off-site) system.
   1. No "stand alone" controls allowed unless approved by Owner / Engineer
   2. Graphics packages on Owner's central (off-site) system will display specific alarms, setpoints, temperatures, flows, etc.
   3. Equipment scheduling to be programmable via Owner's central (off-site) system

B. Network: Install communication bus between LCU's to allow system interface through dedicated workstation, terminal device, and web server.

C. Programming: Configure, download, test, and debug software codes per LCU-type to match intended application specific, custom, or project-drawing-listed sequences of operation.

END OF SECTION

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Single conductor building wire.

B. Service entrance cable.

C. Metal-clad cable.

D. Wire and cable for 600 volts and less.

E. Wiring connectors.

F. Electrical tape.

G. Heat shrink tubing.

H. Oxide inhibiting compound.

I. Wire pulling lubricant.

J. Cable ties.

1.2 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 26 0505 - Selective Demolition for Electrical: Disconnection, removal, and/or extension of existing electrical conductors and cables.

C. Section 26 0526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.

D. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.3 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013 (Reapproved 2018).

B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2011 (Reapproved 2017).

C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010 (Reapproved 2014).

D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2014).

E. ASTM B800 - Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes - Annealed and Intermediate Tempers; 2005 (Reapproved 2015).

F. ASTM B801 - Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy Wire for Subsequent Covering of Insulation; 2016.

G. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape; 2017.

H. ASTM D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes; 2013.

I. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

J. NECA 104 - Recommended Practice for Installing Aluminum Building Wire and Cable; 2012.

K. NECA 120 - Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC); 2012.

L. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy; 2009.

M. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

N. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

O. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.

P. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.

Q. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.

R. UL 486C - Splicing Wire Connectors; Current Edition, Including All Revisions.

S. UL 486D - Sealed Wire Connector Systems; Current Edition, Including All Revisions.

T. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape; Current Edition, Including All Revisions.

U. UL 1569 - Metal-Clad Cables; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
3. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

1.8 FIELD CONDITIONS

A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify DEDC, LLC and obtain direction before proceeding with work.

PART 2 PRODUCTS

2.1 CONDUCTOR AND CABLE APPLICATIONS

A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.

B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.

C. Concealed Dry Interior Locations: Use only building wire in raceway or metal clad cable.

D. Exposed Dry Interior Locations: Use only building wire in raceway.

E. Above Accessible Ceilings: Use only building wire in raceway or metal clad cable.

F. Wet or Damp Interior Locations: Use only building wire in raceway.

G. Exterior Locations: Use only building wire with Type THWN-2 insulation in raceway.

H. Use solid conductor for feeders and branch circuits 10 AWG and smaller.

I. Use stranded conductors for control circuits.

J. Use conductor not smaller than 12 AWG for power and lighting circuits.

K. Use conductor not smaller than 14 AWG for control circuits.

L. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet.

2.2 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

A. Provide products that comply with requirements of NFPA 70.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.

D. Comply with NEMA WC 70.

E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.

F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.

G. Conductors for Grounding and Bonding: Also comply with Section 26 0526.

H. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.

I. Conductor Material:
   1. Provide copper conductors except where aluminum conductors are specifically indicated or permitted for substitution. Conductor sizes indicated are based on copper unless specifically indicated as aluminum. Conductors designated with the abbreviation "AL" indicate aluminum.
      a. Substitution of aluminum conductors for copper is permitted, when approved by Owner and authority having jurisdiction, only for the following:
         1) Services: Copper conductors size 1/0 AWG and larger.
         2) Feeders: Copper conductors size 1/0 AWG and larger.
      b. Where aluminum conductors are substituted for copper, comply with the following:
         1) Size aluminum conductors to provide, when compared to copper sizes indicated, equivalent or greater ampacity and equivalent or less voltage drop.
         2) Increase size of raceways, boxes, wiring gutters, enclosures, etc. as required to accommodate aluminum conductors.

3) Provide aluminum equipment grounding conductor sized according to NFPA 70.
4) Equip electrical distribution equipment with compression lugs for terminating aluminum conductors.

2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
3. Tinned Copper Conductors: Comply with ASTM B33.
4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.

J. Minimum Conductor Size:
1. Branch Circuits: 12 AWG.
a. Exceptions:
1) 20 A, 120 V circuits longer than 75 feet: 10 AWG, for voltage drop.
2) 20 A, 120 V circuits longer than 150 feet: 8 AWG, for voltage drop.
2. Control Circuits: 14 AWG.

K. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

L. Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
2. Color Coding Method: Integrally colored insulation.
a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
3. Color Code:
a. 208Y/120 V, 3 Phase, 4 Wire System:
1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.
4) Neutral/Grounded: White.
b. Equipment Ground, All Systems: Green.
c. Travelers for 3-Way and 4-Way Switching: Pink.
d. For control circuits, comply with manufacturer's recommended color code.

2.3 SINGLE CONDUCTOR BUILDING WIRE

A. Manufacturers:
1. Copper Building Wire:
a. Cerro Wire LLC: www.cerrowire.com/#sle.
b. Encore Wire Corporation: www.encorewire.com/#sle.
c. General Cable Technologies Corporation; _____: www.generalcable.com/#sle.
d. Southwire Company: www.southwire.com/#sle.
e. Substitutions: See Section 01 6000 - Product Requirements.
2. Aluminum Building Wire (only where specifically indicated or permitted for substitution):

a. Encore Wire Corporation: www.encorewire.com/#sle.
b. Southwire Company: www.southwire.com/#sle.
c. Stabiloy, a brand of General Cable Technologies Corporation; _____: www.stabiloy.com/#sle.
d. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: Single conductor insulated wire.

C. Conductor Stranding:
1. Feeders and Branch Circuits:
a. Size 10 AWG and Smaller: Solid.
b. Size 8 AWG and Larger: Stranded.
2. Control Circuits: Stranded.

D. Insulation Voltage Rating: 600 V.

E. Insulation:
1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.
a. Size 4 AWG and Larger: Type XHHW-2.
b. Installed Underground: Type XHHW-2.

F. Conductor: Copper.

G. Insulation Voltage Rating: 600 volts.

H. Insulation: NFPA 70, Type THHN/THWN.

I. Insulation: Thermoplastic material rated 75 degrees C.

2.4 METAL-CLAD CABLE

A. Manufacturers:
1. AFC Cable Systems Inc: www.afcweb.com/#sle.
2. Encore Wire Corporation: www.encorewire.com/#sle.
3. Southwire Company: www.southwire.com/#sle.

B. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.

C. Conductor Stranding:
1. Size 10 AWG and Smaller: Solid.
2. Size 8 AWG and Larger: Stranded.

D. Insulation Voltage Rating: 600 V.

E. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.

F. Provide dedicated neutral conductor for each phase conductor where indicated or required.

G. Grounding: Full-size integral equipment grounding conductor.

H. Armor: Steel, interlocked tape.

I. Description: NFPA 70, Type MC.

J. Conductor: Copper.

K. Insulation Voltage Rating: 600 volts.

L. Insulation Temperature Rating: 75 degrees C.

M. Insulation Material: Thermoplastic.

N. Armor Material: Steel.

O. Armor Design: Interlocked metal tape.

2.5 WIRING CONNECTORS

A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

B. Connectors for Grounding and Bonding: Comply with Section 26 0526.

C. Wiring Connectors for Splices and Taps:
1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
3. Connectors for Aluminum Conductors: Use compression connectors.

D. Wiring Connectors for Terminations:
1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.
3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
4. Provide motor pigtail connectors for connecting motor leads in order to facilitate disconnection.
5. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
6. Stranded Conductors Size 10 AWG and Smaller: Use crimped terminals for connections to terminal screws.
7. Conductors for Control Circuits: Use crimped terminals for all connections.

E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.

F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

G. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.

H. Mechanical Connectors: Provide bolted type or set-screw type.

I. Compression Connectors: Provide circumferential type or hex type crimp configuration.

J. Crimped Terminals: Nylon-insulated, with insulation grip and terminal configuration suitable for connection to be made.

2.6 ACCESSORIES

A. Electrical Tape:
   1. Manufacturers:
      a. 3M: www.3m.com/#sle.
      b. Substitutions: See Section 01 6000 - Product Requirements.
   2. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
   3. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
   4. Rubber Splicing Electrical Tape: Ethylene Propylene Rubber (EPR) tape, complying with ASTM D4388; minimum thickness of 30 mil; suitable for continuous temperature environment up to 194 degrees F and short-term 266 degrees F overload service.
   5. Electrical Filler Tape: Rubber-based insulating moldable putty, minimum thickness of 125 mil; suitable for continuous temperature environment up to 176 degrees F.
   6. Varnished Cambric Electrical Tape: Cotton cambric fabric tape, with or without adhesive, oil-primed and coated with high-grade insulating varnish; minimum thickness of 7 mil; suitable for continuous temperature environment up to 221 degrees F.
   7. Moisture Sealing Electrical Tape: Insulating mastic compound laminated to flexible, all-weather vinyl backing; minimum thickness of 90 mil.

B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.

C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.

D. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.

E. Cable Ties: Material and tensile strength rating suitable for application.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that work likely to damage wire and cable has been completed.

C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.

D. Verify that raceway installation is complete and supported.

E. Verify that field measurements are as indicated.

F. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.3 INSTALLATION

A. Circuiting Requirements:
   1. Unless dimensioned, circuit routing indicated is diagrammatic.
   2. When circuit destination is indicated without specific routing, determine exact routing required.
   3. Arrange circuiting to minimize splices.
   4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
   5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
   6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
   7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
   8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among up to three single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.

B. Install products in accordance with manufacturer's instructions.

C. Perform work in accordance with NECA 1 (general workmanship).

D. Install aluminum conductors in accordance with NECA 104.

E. Install metal-clad cable (Type MC) in accordance with NECA 120.

F. Installation in Raceway:
   1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
   2. Pull all conductors and cables together into raceway at same time.
   3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
   4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.

G. Exposed Cable Installation (only where specifically permitted):
   1. Route cables parallel or perpendicular to building structural members and surfaces.
   2. Protect cables from physical damage.

H. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.

I. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
   1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
   2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.

J. Terminate cables using suitable fittings.
   1. Metal-Clad Cable (Type MC):
      a. Use listed fittings.
      b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.

K. Install conductors with a minimum of 12 inches of slack at each outlet.

L. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.

M. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

N. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.

O. Make wiring connections using specified wiring connectors.
   1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
   2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
   3. Do not remove conductor strands to facilitate insertion into connector.

4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

P. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
   1. Dry Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
      a. For taped connections, first apply adequate amount of rubber splicing electrical tape or electrical filler tape, followed by outer covering of vinyl insulating electrical tape.
      b. For taped connections likely to require re-entering, including motor leads, first apply varnished cambric electrical tape, followed by adequate amount of rubber splicing electrical tape, followed by outer covering of vinyl insulating electrical tape.
   2. Damp Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
      a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
      b. For taped connections, follow same procedure as for dry locations but apply outer covering of moisture sealing electrical tape.
   3. Wet Locations: Use heat shrink tubing.

Q. Insulate ends of spare conductors using vinyl insulating electrical tape.

R. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.

S. Color Code Legend: Provide identification label identifying color code for ungrounded conductors at each piece of feeder or branch-circuit distribution equipment.

T. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

U. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

V. Install wire and cable securely, in a neat and workmanlike manner, as specified in NECA 1.

W. Route wire and cable as required to meet project conditions.
   1. Wire and cable routing indicated is approximate unless dimensioned.
   2. Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.

X. Use wiring methods indicated.

Y. Pull all conductors into raceway at same time.

Z. Use suitable wire pulling lubricant for building wire 4 AWG and larger.

AA. Protect exposed cable from damage.

AB. Support cables above accessible ceiling, using spring metal clips or metal cable ties to support cables from structure or ceiling suspension system. Do not rest cable on ceiling panels.

AC. Use suitable cable fittings and connectors.

AD. Neatly train and lace wiring inside boxes, equipment, and panelboards.

AE. Clean conductor surfaces before installing lugs and connectors.

AF. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

AG. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.

AH. Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.

AI. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.

AJ. Identify and color code wire and cable under provisions of Section 26 0553. Identify each conductor with its circuit number or other designation indicated.

3.4 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Perform field inspection and testing in accordance with Section 01 4000.

C. Inspect and test in accordance with NETA ATS, except Section 4.

D. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.

E. Correct deficiencies and replace damaged or defective conductors and cables.

F. Perform inspections and tests listed in NETA STD ATS, Section 7.3.2.

END OF SECTION

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Grounding and bonding requirements.

B. Conductors for grounding and bonding.

C. Connectors for grounding and bonding.

D. Ground bars.

E. Ground rod electrodes.

F. Grounding and bonding components.

G. Provide all components necessary to complete the grounding system(s) consisting of:
   1. Existing metal underground water pipe.
   2. Metal underground water pipe.
   3. Metal frame of the building.
   4. Metal underground gas piping system.
   5. Rod electrodes.

1.2 RELATED REQUIREMENTS

A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
   1. Includes oxide inhibiting compound.

B. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

C. Section 03 3000 - Cast-in-Place Concrete.

1.3 REFERENCE STANDARDS

A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System; 2012.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

C. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings; 2007.

D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Verify exact locations of underground metal water service pipe entrances to building.
2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
3. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.5 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: 5 ohms.

1.6 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.

C. Test Reports: Indicate overall resistance to ground and resistance of each electrode.

1.7 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING REQUIREMENTS

A. Do not use products for applications other than as permitted by NFPA 70 and product listing.

B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.

C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

D. Grounding System Resistance:
   1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by DEDC, LLC. Precipitation within the previous 48 hours does not constitute normally dry conditions.
   2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
   3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.

E. Grounding Electrode System:
   1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
      a. Provide continuous grounding electrode conductors without splice or joint.
      b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
   2. Metal Underground Water Pipe(s):
      a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
      b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
      c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
   3. Metal In-Ground Support Structure:
      a. Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with NFPA 70.
   4. Concrete-Encased Electrode:
      a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
   5. Ground Rod Electrode(s):
      a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
      b. Space electrodes not less than 10 feet from each other and any other ground electrode.
      c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.

6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
7. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
   a. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
   b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.
   c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

F. Service-Supplied System Grounding:
1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.

G. Separately Derived System Grounding:
1. Separately derived systems include, but are not limited to:
   a. Transformers (except autotransformers such as buck-boost transformers).
2. Provide grounding electrode conductor to connect derived system grounded conductor to nearest effectively grounded metal building frame. Unless otherwise indicated, make connection at neutral (grounded) bus in source enclosure.
3. Provide bonding jumper to connect derived system grounded conductor to nearest metal building frame and nearest metal water piping in the area served by the derived system, where not already used as a grounding electrode for the derived system. Make connection at same location as grounding electrode conductor connection.
4. Outdoor Source: Where the source of the separately derived system is located outside the building or structure supplied, provide connection to grounding electrode at source in accordance with NFPA 70.
5. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.
6. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.

H. Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.

3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
   a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
   b. Metal gas piping.
8. Provide bonding for metal building frame.
9. Provide bonding for metal siding not effectively bonded through attachment to metal building frame.

I. Communications Systems Grounding and Bonding:
   1. Provide intersystem bonding termination at service equipment or metering equipment enclosure and at disconnecting means for any additional buildings or structures in accordance with NFPA 70.
   2. Provide bonding jumper in raceway from intersystem bonding termination to each communications room or backboard and provide ground bar for termination.
      a. Bonding Jumper Size: 6 AWG, unless otherwise indicated or required.
      b. Raceway Size: 3/4 inch trade size unless otherwise indicated or required.
      c. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
      d. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

2.2 GROUNDING AND BONDING COMPONENTS

A. General Requirements:
   1. Provide products listed, classified, and labeled as suitable for the purpose intended.
   2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 0526:
   1. Use insulated copper conductors unless otherwise indicated.
      a. Exceptions:
         1) Use bare copper conductors where installed underground in direct contact with earth.
         2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:
   1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
   2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
   3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.

D. Ground Bars:
   1. Description: Copper rectangular ground bars with mounting brackets and insulators.
   2. Size: As indicated.
   3. Holes for Connections: As indicated or as required for connections to be made.

E. Ground Rod Electrodes:
   1. Comply with NEMA GR 1.
   2. Material: Copper-bonded (copper-clad) steel.
   3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.

F. Oxide Inhibiting Compound: Comply with Section 26 0519.

2.3 MANUFACTURERS

A. Cooper Power Systems, a division of Cooper Industries: www.cooperindustries.com.

B. Substitutions: See Section 01 6000 - Product Requirements.

2.4 ELECTRODES

A. Manufacturers:
   1. Cooper Power Systems, a division of Cooper Industries: www.cooperindustries.com.
   2. Substitutions: See Section 01 6000 - Product Requirements.

B. Rod Electrodes: Copper-clad steel.
   1. Diameter: 3/4 inch.
   2. Length: 10 feet.
   3. Substitutions: See Section 01 6000 - Product Requirements.

2.5 CONNECTORS AND ACCESSORIES

A. Mechanical Connectors: Bronze.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.

B. Verify that field measurements are as indicated.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Verify existing conditions prior to beginning work.

E. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
   1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.

D. Make grounding and bonding connections using specified connectors.
   1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
   2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
   3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
   4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
   5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

E. Identify grounding and bonding system components in accordance with Section 26 0553.

F. Install ground electrodes at locations indicated. Install additional rod electrodes as required to achieve specified resistance to ground.

G. Provide grounding electrode conductor and connect to reinforcing steel in foundation footing where indicated. Bond steel together.

H. Provide bonding to meet requirements described in Quality Assurance.

I. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.13.

D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.

E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

END OF SECTION

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.2 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.

B. Section 26 0533.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.

C. Section 26 0533.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.

D. Section 26 0548 - Vibration and Seismic Controls for Electrical Systems.

E. Section 26 5100 - Interior Lighting: Additional support and attachment requirements for interior luminaires.

F. Conduit and equipment supports.

G. Anchors and fasteners.

1.3 REFERENCE STANDARDS

A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.

B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2016a.

C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2015.

D. MFMA-4 - Metal Framing Standards Publication; 2004.

E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 3000.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, non-penetrating rooftop supports, and post-installed concrete and masonry anchors.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Comply with applicable building code.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:
1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of _____. Include consideration for vibration, equipment operation, and shock loads where applicable.

4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
6. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
    b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
    c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
2. Conduit Clamps: Bolted type unless otherwise indicated.

C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.

D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
1. Comply with MFMA-4.
2. Channel Material:
    a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
    b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.

E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
1. Minimum Size, Unless Otherwise Indicated or Required:
    a. Equipment Supports: 1/2 inch diameter.
    b. Single Conduit up to 1 inch (27 mm) trade size: 1/4 inch diameter.
    c. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter.
    d. Trapeze Support for Multiple Conduits: 3/8 inch diameter.
    e. Outlet Boxes: 1/4 inch diameter.
    f. Luminaires: 1/4 inch diameter.

F. Anchors and Fasteners:
1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Wood: Use wood screws.
8. Plastic and lead anchors are not permitted.
9. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.

a. Comply with MFMA-4.
b. Channel Material: Use galvanized steel.
c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

2.2 MANUFACTURERS

A. Thomas & Betts Corporation: www.tnb.com.

B. Threaded Rod Company: www.threadedrod.com.

C. Substitutions: See Section 01 6000 - Product Requirements.

2.3 MATERIALS

A. Hangers, Supports, Anchors, and Fasteners - General: Corrosion-resistant materials of size and type adequate to carry the loads of equipment and conduit, including weight of wire in conduit.

B. Supports: Fabricated of structural steel or formed steel members; galvanized.

C. Anchors and Fasteners:

	Drop in Sleeve Anchors	Expansion Machine Bolt Anchors	Lag Shield Anchors	Nail-in Anchors	Toggle Bolts	Hollow Wall Anchors	Power Driven Studs
Brick	X	X	X	X			X
Concrete	X	X	X	X			X
Concrete Block	X		X	X	X		
Cinder Block		X			X	X	
Stone	X	X		X			X
Marble	X		X				
Building Tile		X			X	X	
Ceramic Tile		X			X		
Terrazzo		X		X			
Terra Cotta		X			X	X	
Plaster					X	X	
Drywall				X	X		
Slate		X			X		
Steel							X

ANCHOR HARDWARE TABLE

D. Formed Steel Channel:

1. Product: Steel "U" shaped with in-turned clamping ridges manufactured by Unitstrut, Power Wtrut, B-Line Strut or Kindorf.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Unless specifically indicated or approved by DEDC, LLC, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by DEDC, LLC, do not provide support from roof deck.

F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

G. Provide required vibration isolation and/or seismic controls in accordance with Section 26 0548.

H. Equipment Support and Attachment:
   1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
   2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
   3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
   4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.

I. Conduit Support and Attachment: Also comply with Section 26 0533.13.

J. Box Support and Attachment: Also comply with Section 26 0533.16.

K. Interior Luminaire Support and Attachment: Also comply with Section 26 5100.

L. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.

M. Secure fasteners according to manufacturer's recommended torque settings.

N. Remove temporary supports.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect support and attachment components for damage and defects.

C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

D. Correct deficiencies and replace damaged or defective support and attachment components.

E. Install hangers and supports as required to adequately and securely support electrical system components, in a neat and workmanlike manner, as specified in NECA 1.
   1. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.
   2. Do not drill or cut structural members.

F. Rigidly weld support members or use hexagon-head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.

G. Install surface-mounted cabinets and panelboards with minimum of four anchors.

H. In wet and damp locations use steel channel supports to stand cabinets and panelboards 1-5/8" off wall.

I. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

END OF SECTION

SECTION 26 0533.13 - CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Flexible metal conduit (FMC).

B. Liquidtight flexible metal conduit (LFMC).

C. Electrical metallic tubing (EMT).

D. Rigid polyvinyl chloride (PVC) conduit.

E. Liquidtight flexible nonmetallic conduit (LFNC).

F. Conduit fittings.

G. Accessories.

H. Conduit, fittings and conduit bodies.

1.2 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Concrete encasement of conduits.

B. Section 07 8400 - Firestopping.

C. Section 26 0526 - Grounding and Bonding for Electrical Systems.
   1. Includes additional requirements for fittings for grounding and bonding.

D. Section 26 0529 - Hangers and Supports for Electrical Systems.

E. Section 26 0548 - Vibration and Seismic Controls for Electrical Systems.

F. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

G. Section 26 2100 - Low-Voltage Electrical Service Entrance: Additional requirements for electrical service conduits.

H. Section 27 1000 - Structured Cabling: Additional requirements for communications systems conduits.

I. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.

1.3 REFERENCE STANDARDS

A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2015.

B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S); 2015.

C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit (EIMC); 2005.

D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2013.

F. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC); 2003.

G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.

H. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit; 2018.

I. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2013.

J. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2016.

K. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

L. UL 1 - Flexible Metal Conduit; Current Edition, Including All Revisions.

M. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.

N. UL 360 - Liquid-Tight Flexible Steel Conduit; Current Edition, Including All Revisions.

O. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.

P. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.

Q. UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.

R. UL 1242 - Electrical Intermediate Metal Conduit-Steel; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
   2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
   3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
   4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.

5. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.

C. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2 inch (53 mm) trade size and larger.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and shown.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

B. Accept conduit on site. Inspect for damage.

C. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.

B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.

C. Underground:
1. Under Slab on Grade: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).

2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
3. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
4. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.

D. Embedded Within Concrete:
1. Within Slab on Grade: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
2. Within Slab Above Ground: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
3. Where electrical metallic tubing (EMT) emerges from concrete into salt air, use corrosion protection tape to provide supplementary corrosion protection for a minimum of 4 inches on either side of where conduit emerges or use PVC-coated galvanized steel rigid metal conduit.

E. Concealed Within Masonry Walls: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).

F. Concealed Within Hollow Stud Walls: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).

G. Concealed Above Accessible Ceilings: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).

H. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.

I. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).

J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
1. Locations subject to physical damage include, but are not limited to:
a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
b. Where exposed below 20 feet in warehouse areas.

K. Exposed, Exterior: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal conduit.

L. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).

M. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.

1. Maximum Length: 6 feet.

N. Connections to Vibrating Equipment:
   1. Dry Locations: Use flexible metal conduit.
   2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
   3. Maximum Length: 6 feet unless otherwise indicated.
   4. Vibrating equipment includes, but is not limited to:
      a. Transformers.
      b. Motors.
      c. Genset.
      d. Mechanical HVAC equipment

O. Fished in Existing Walls, Where Necessary: Use flexible metal conduit.

2.2 CONDUIT REQUIREMENTS

A. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling a mandrel through them.

B. Electrical Service Conduits: Also comply with Section 26 2100.

C. Communications Systems Conduits: Also comply with Section 27 1000.

D. Fittings for Grounding and Bonding: Also comply with Section 26 0526.

E. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.

F. Provide products listed, classified, and labeled as suitable for the purpose intended.

G. Minimum Conduit Size, Unless Otherwise Indicated:
   1. Branch Circuits: 3/4 inch (21 mm) trade size.
   2. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.
   3. Control Circuits: 1/2 inch (16 mm) trade size.
   4. Flexible Connections to Luminaires: 1/2 inch (16 mm) trade size.
   5. Underground, Interior: 3/4 inch (21 mm) trade size.
   6. Underground, Exterior: 1 inch (27 mm) trade size.

H. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.3 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

A. Manufacturers:
   1. Allied Tube & Conduit: www.alliedeg.com/#sle.
   2. Republic Conduit: www.republic-conduit.com/#sle.
   3. Wheatland Tube, a Division of Zekelman Industries: www.wheatland.com/#sle.

4. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.

C. Fittings:
   1. Manufacturers:
      a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
      b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
      c. Thomas & Betts Corporation: www.tnb.com/#sle.
      d. _____.
   2. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   3. Material: Use steel or malleable iron.
      a. Do not use die cast zinc fittings.
   4. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.4 INTERMEDIATE METAL CONDUIT (IMC)

A. Manufacturers:
   1. Allied Tube & Conduit: www.alliedeg.com/#sle.
   2. Republic Conduit: www.republic-conduit.com/#sle.
   3. Wheatland Tube, a Division of Zekelman Industries: www.wheatland.com/#sle.
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.

C. Fittings:
   1. Manufacturers:
      a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
      b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
      c. Thomas & Betts Corporation: www.tnb.com/#sle.
      d. Substitutions: See Section 01 6000 - Product Requirements.
   2. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   3. Material: Use steel or malleable iron.
   4. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

D. Conduit Size: Comply with NFPA 70.
   1. Minimum Size: 3/4 inch unless otherwise specified.

E. Outdoor Locations Above Grade: Use rigid steel conduit.

F. In Slab Above Grade:
   1. Use rigid steel conduit.
   2. Maximum Size Conduit in Slab: 3/4 inch; 1/2 inch for conduits crossing each other.

G. Wet and Damp Locations: Use rigid steel conduit.

H. Dry Locations:
   1. Concealed: Use electrical metallic tubing, where permitted by the NEC.
   2. Exposed: Use electrical metallic tubing, where permitted by the NEC.

2.5 METAL CONDUIT

A. Manufacturers:
   1. Allied Tube & Conduit: www.alliedtube.com.
   2. Wheatland Tube Company: www.wheatland.com.
   3. Triangle
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Rigid Steel Conduit: ANSI C80.1.

C. Fittings and Conduit Bodies: NEMA FB 1; material to match conduit.

2.6 PVC-COATED GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

A. Manufacturers:
   1. Thomas & Betts Corporation; _____: www.tnb.com/#sle.
   2. Robroy Industries; _____: www.robroy.com/#sle.
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit with external polyvinyl chloride (PVC) coating complying with NEMA RN 1 and listed and labeled as complying with UL 6.

C. Exterior Coating: Polyvinyl chloride (PVC), nominal thickness of 40 mil.

D. PVC-Coated Fittings:
   1. Manufacturer: Same as manufacturer of PVC-coated conduit to be installed.
   2. Non-Hazardous Locations: Use fittings listed and labeled as complying with UL 514B.
   3. Material: Use steel or malleable iron.
   4. Exterior Coating: Polyvinyl chloride (PVC), minimum thickness of 40 mil.

E. PVC-Coated Supports: Furnish with exterior coating of polyvinyl chloride (PVC), minimum thickness of 15 mil.

2.7 FLEXIBLE METAL CONDUIT (FMC)

A. Manufacturers:
   1. AFC Cable Systems, Inc; _____: www.afcweb.com/#sle.

2. Electri-Flex Company; _____: www.electriflex.com/#sle.
3. International Metal Hose; _____: www.metalhose.com/#sle.
4. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.

C. Fittings:
1. Manufacturers:
a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
c. Thomas & Betts Corporation: www.tnb.com/#sle.
d. Substitutions: See Section 01 6000 - Product Requirements.
2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
3. Material: Use steel or malleable iron.
a. Do not use die cast zinc fittings.

D. Description: Interlocked steel construction.

E. Fittings: NEMA FB 1.

2.8 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Manufacturers:
1. AFC Cable Systems, Inc; _____: www.afcweb.com/#sle.
2. Electri-Flex Company; _____: www.electriflex.com/#sle.
3. International Metal Hose; _____: www.metalhose.com/#sle.
4. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.

C. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
a. Do not use die cast zinc fittings.

D. Description: Interlocked steel construction with PVC jacket.

E. Fittings: NEMA FB 1.

2.9 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:
1. Allied Tube & Conduit; _____: www.alliedeg.com/#sle.
2. Wheatland Tube, a Division of Zekelman Industries; _____: www.wheatland.com/#sle.
3. Triangle

4. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

C. Fittings:
1. Manufacturers:
a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
c. Thomas & Betts Corporation: www.tnb.com/#sle.
d. Substitutions: See Section 01 6000 - Product Requirements.
2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
3. Material: Use steel or malleable iron.
a. Do not use die cast zinc fittings.
4. Connectors and Couplings: Use compression (gland) or set-screw type.
a. Do not use indenter type connectors and couplings.
5. Damp or Wet Locations (where permitted): Use fittings listed for use in wet locations.
6. Embedded Within Concrete (where permitted): Use fittings listed as concrete-tight. Fittings that require taping to be concrete-tight are acceptable.

D. Description: ANSI C80.3; galvanized tubing.

E. Fittings and Conduit Bodies: NEMA FB 1; steel or malleable iron compression type.

2.10 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

A. Manufacturers:
1. Cantex Inc: www.cantexinc.com/#sle.
2. Carlon, a brand of Thomas & Betts Corporation: www.carlon.com/#sle.
3. JM Eagle: www.jmeagle.com/#sle.
4. _____.
5. Substitutions: See Section 01 6000 - Product Requirements.

B. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.

C. Fittings:
1. Manufacturer: Same as manufacturer of conduit to be connected.
2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.11 ACCESSORIES

A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.

B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.

C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.

D. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.

E. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.

F. Duct Bank Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for concrete encasement in open trench installation; suitable for the conduit/duct arrangement to be installed.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive conduits.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Conduit routing is shown on drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.

D. Install intermediate metal conduit (IMC) in accordance with NECA 101.

E. Install PVC-coated galvanized steel rigid metal conduit (RMC) using only tools approved by the manufacturer.

F. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.

G. Conduit Routing:
   1. Unless dimensioned, conduit routing indicated is diagrammatic.
   2. When conduit destination is indicated without specific routing, determine exact routing required.
   3. Conceal all conduits unless specifically indicated to be exposed.
   4. Conduits in the following areas may be exposed, unless otherwise indicated:
      a. Electrical rooms.

b. Mechanical equipment rooms.
c. Within joists in areas with no ceiling.

5. Unless otherwise approved, do not route conduits exposed:
   a. Across floors.
   b. Across roofs.
   c. Across top of parapet walls.
   d. Across building exterior surfaces.
6. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
7. Arrange conduit to maintain adequate headroom, clearances, and access.
8. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
9. Arrange conduit to provide no more than 150 feet between pull points.
10. Route conduits above water and drain piping where possible.
11. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
12. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
13. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
    a. Heaters.
    b. Hot water piping.
    c. Flues.
14. Group parallel conduits in the same area together on a common rack.

H. Conduit Support:
1. Secure and support conduits in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide required vibration isolation and/or seismic controls in accordance with Section 26 0548.
3. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
4. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
5. Use conduit strap to support single surface-mounted conduit.
   a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
6. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
7. Use conduit clamp to support single conduit from beam clamp or threaded rod.
8. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
9. Use non-penetrating rooftop supports to support conduits routed across rooftops (only where approved).
10. Use of wire for support of conduits is not permitted.

11. Where conduit support intervals specified in NFPA 70 and NECA standards differ, comply with the most stringent requirements.

I. Connections and Terminations:
   1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
   2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
   3. Use suitable adapters where required to transition from one type of conduit to another.
   4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
   5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
   6. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
   7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.

J. Penetrations:
   1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
   2. Make penetrations perpendicular to surfaces unless otherwise indicated.
   3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
   4. Conceal bends for conduit risers emerging above ground.
   5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
   6. Provide suitable modular seal where conduits penetrate exterior wall below grade.
   7. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
   8. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
   9. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

K. Underground Installation:
   1. Provide trenching and backfilling in accordance with Section 31 2316.13.
   2. Minimum Cover, Unless Otherwise Indicated or Required:
      a. Underground, Exterior: 36 inches.
      b. Under Slab on Grade: 12 inches to bottom of slab.
   3. Provide underground warning tape in accordance with Section 26 0553 along entire conduit length for service entrance where not concrete-encased.

L. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 03 3000 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.

M. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
   1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
   2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
   3. Where conduits are subject to earth movement by settlement or frost.

N. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
   1. Where conduits pass from outdoors into conditioned interior spaces.
   2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.

O. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.

P. Provide grounding and bonding in accordance with Section 26 0526.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C. Where coating of PVC-coated galvanized steel rigid metal conduit (RMC) contains cuts or abrasions, repair in accordance with manufacturer's instructions.

D. Correct deficiencies and replace damaged or defective conduits.

3.4 CLEANING

A. Clean interior of conduits to remove moisture and foreign matter.

3.5 PROTECTION

A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

B. Install conduit securely, in a neat and workmanlike manner, as specified in NECA 1.

C. Install steel conduit as specified in NECA 101.

D. Arrange supports to prevent misalignment during wiring installation.

E. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

F. Group related conduits; support using conduit rack. Construct rack using steel channel .

G. Fasten conduit supports to building structure and surfaces under provisions of Section 26 0529.

H. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.

I. Do not attach conduit to ceiling support wires.

J. Arrange conduit to maintain headroom and present neat appearance.

K. Route conduit parallel and perpendicular to walls.

L. Route conduit installed above accessible ceilings parallel and perpendicular to walls.

M. Route conduit in and under slab from point-to-point.

N. Maintain adequate clearance between conduit and piping.

O. Maintain 12 inch clearance between conduit and surfaces with temperatures exceeding 104 degrees F.

P. Cut conduit square using saw or pipecutter; de-burr cut ends.

Q. Bring conduit to shoulder of fittings; fasten securely.

R. Use conduit hubs to fasten conduit to sheet metal boxes in damp and wet locations.

S. Install no more than equivalent of three 90 degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one shot bender to fabricate bends in metal conduit larger than 2 inch size.

T. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

U. Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic.

V. Provide suitable pull string in each empty conduit except sleeves and nipples.

W. Use suitable caps to protect installed conduit against entrance of dirt and moisture.

X. Ground and bond conduit under provisions of Section 26 0526.

Y. Identify conduit under provisions of Section 26 0553.

3.6 INTERFACE WITH OTHER PRODUCTS

A. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

B. Route conduit through roof openings for piping and ductwork wherever possible. Where separate roofing penetration is required, coordinate location and installation method with roofing installation specified in Section 01700.

END OF SECTION

SECTION 26 0533.16 - BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.

B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.

C. Boxes and enclosures for integrated power, data, and audio/video.

D. Floor boxes.

E. Wall and ceiling outlet boxes.

F. Pull and junction boxes.

1.2 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 08 3100 - Access Doors and Panels: Panels for maintaining access to concealed boxes.

C. Section 26 0526 - Grounding and Bonding for Electrical Systems.

D. Section 26 0529 - Hangers and Supports for Electrical Systems.

E. Section 26 0533.13 - Conduit for Electrical Systems:
   1. Conduit bodies and other fittings.
   2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.

F. Section 26 0548 - Vibration and Seismic Controls for Electrical Systems.

G. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

H. Section 26 2726 - Wiring Devices:
   1. Wall plates.
   2. Additional requirements for locating boxes for wiring devices.

I. Section 27 1000 - Structured Cabling: Additional requirements for communications systems outlet boxes.

1.3 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

B. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2010.

C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.

D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; 2013.

E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2018.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

H. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

I. UL 508A - Industrial Control Panels; 2013.

J. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
   4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
   5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
   6. Coordinate the work with other trades to preserve insulation integrity.
   7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
   8. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground handhole enclosures.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

B. Products: Provide products listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 BOXES

A. General Requirements:
   1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
   2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
   3. Provide products listed, classified, and labeled as suitable for the purpose intended.
   4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
   5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
   1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
   2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
   3. Use suitable concrete type boxes where flush-mounted in concrete.
   4. Use suitable masonry type boxes where flush-mounted in masonry walls.
   5. Use raised covers suitable for the type of wall construction and device configuration where required.
   6. Use shallow boxes where required by the type of wall construction.
   7. Do not use "through-wall" boxes designed for access from both sides of wall.
   8. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
   9. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
   10. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
   11. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
   12. Wall Plates: Comply with Section 26 2726.

C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:

1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
2. NEMA 250 Environment Type, Unless Otherwise Indicated:
   a. Indoor Clean, Dry Locations: Type 1, painted steel.
   b. Outdoor Locations: Type 3R, painted steel.
3. Junction and Pull Boxes Larger Than 100 cubic inches:
   a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
   a. Back Panels: Painted steel, removable.
5. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.

D. Boxes and Enclosures for Integrated Power, Data, and Audio/Video: Size and configuration as indicated or as required with partitions to separate services; field-connected gangable boxes may be used.

2.2 MANUFACTURERS

A. Appleton Electric: www.appletonelec.com.

B. Hoffman

C. Steel City

D. Crouse-Hinds

E. Substitutions: See Section 01 6000 - Product Requirements.

2.3 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel.
   1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 1/2 inch male fixture studs where required.

B. Cast Boxes: NEMA FB 1, Type FD, aluminum. Provide gasketed cover by box manufacturer. Provide threaded hubs.

C. Wall Plates for Finished Areas: As specified in Section 26 2726.

2.4 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: NEMA OS 1, galvanized steel.

B. Surface Mounted Cast Metal Box: NEMA 250, Type 4; flat-flanged, surface mounted junction box:
   1. Material: Galvanized cast iron.
   2. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive boxes.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.

E. Box Locations:
   1. Locate boxes to be accessible. Provide access panels in accordance with Section 08 3100 as required where approved by the Architect.
   2. Locate boxes as required for devices installed under other sections or by others.
      a. Switches, Receptacles, and Other Wiring Devices: Comply with Section 26 2726.
      b. Communications Systems Outlets: Comply with Section 27 1000.
   3. Locate boxes so that wall plates do not span different building finishes.
   4. Locate boxes so that wall plates do not cross masonry joints.
   5. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
   6. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
   7. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
      a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
      b. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.
   8. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 0533.13.

9. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
    a. Concealed above accessible suspended ceilings.
    b. Within joists in areas with no ceiling.
    c. Electrical rooms.
    d. Mechanical equipment rooms.

F. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide required seismic controls in accordance with Section 26 0548.
3. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
4. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
5. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.

G. Install boxes plumb and level.

H. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.

I. Install boxes as required to preserve insulation integrity.

J. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

K. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

L. Close unused box openings.

M. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.

N. Provide grounding and bonding in accordance with Section 26 0526.

O. Identify boxes in accordance with Section 26 0553.

P. Install boxes securely, in a neat and workmanlike manner, as specified in NECA 1.

Q. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and as required by NFPA 70.

R. Set wall mounted boxes at elevations to accommodate mounting heights indicated.

S. Electrical boxes are shown on Drawings in approximate locations unless dimensioned.
   1. Adjust box locations up to 10 feet if required to accommodate intended purpose.

T. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726.

U. Maintain headroom and present neat mechanical appearance.

V. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.

W. Install boxes to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

X. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.

Y. Use flush mounting outlet box in finished areas.

Z. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

AA. Do not install flush mounting box back-to-back in walls; provide minimum 6 inches separation. Provide minimum 24 inches separation in acoustic rated walls.

AB. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

AC. Do not fasten boxes to ceiling support wires.

AD. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.

AE. Use gang box where more than one device is mounted together. Do not use sectional box.

AF. Use cast outlet box in exterior locations exposed to the weather and wet locations.

AG. Use cast floor boxes for installations in slab on grade; formed steel boxes are acceptable for other installations.

3.3 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closures in unused box openings.

3.4 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

3.5 PROTECTION

A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

B. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical identification requirements.

B. Large Device Identification.

C. Nameplates and Labels.

D. Wire and cable markers.

E. Voltage markers.

F. Underground warning tape.

G. Warning signs and labels.

1.2 RELATED REQUIREMENTS

A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.

B. Section 26 0536 - Cable Trays for Electrical Systems: Additional identification requirements for cable tray systems.

C. Section 26 0573 - Power System Studies: Arc flash hazard warning labels.

D. Section 26 2726 - Wiring Devices - Lutron: Device and wallplate finishes; factory pre-marked wallplates.

E. Section 27 1000 - Structured Cabling: Identification for communications cabling and devices.

F. Section 27 10 00 - Data & Voice Communications Cabling: Identification for communications cabling and devices.

1.3 REFERENCE STANDARDS

A. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs; 2011.

B. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels; 2011.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. UL 969 - Marking and Labeling Systems; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.

B. Sequencing:
   1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.
   2. Do not install identification products until final surface finishes and painting are complete.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.

C. Shop Drawings: Provide schedule of items to be identified indicating proposed designations, materials, legends, and formats.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.7 FIELD CONDITIONS

A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

PART 2 PRODUCTS

2.1 IDENTIFICATION REQUIREMENTS

A. Existing Work: Unless specifically excluded, identify existing elements to remain that are not already identified in accordance with specified requirements.

B. Identification for Equipment:
   1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
      a. Panelboards:
         1) Identify ampere rating.
         2) Identify voltage and phase.
         3) Identify power source and circuit number. Include location when not within sight of equipment.
         4) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.

5) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.

b. Enclosed switches, circuit breakers, and motor controllers:
1) Identify power source and circuit number. Include location when not within sight of equipment.
2) Identify load(s) served. Include location when not within sight of equipment.

c. Time Switches:
1) Identify load(s) served and associated circuits controlled. Include location.

d. Transfer Switches:
1) Identify voltage and phase.
2) Identify short circuit current rating based on the specific overcurrent protective device type and settings protecting the transfer switch.

2. Service Equipment:
a. Use identification nameplate to identify each service disconnecting means.

3. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".

4. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70, including but not limited to the following.
a. Service equipment.

5. Arc Flash Hazard Warning Labels: Comply with Section 26 0573.

C. Identification for Conductors and Cables:
1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 0519.
2. Identification for Communications Conductors and Cables: Comply with Section 27 1000.
3. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

D. Identification for Raceways:

E. Identification for Cable Tray: Comply with Section 26 0536.

F. Identification for Boxes:
1. Use voltage markers to identify highest voltage present.
2. Use identification labels or handwritten text using indelible marker to identify circuits enclosed.

G. Identification for Devices:
1. Identification for Communications Devices: Comply with Section 27 10 00.
2. Wiring Device and Wallplate Finishes: Comply with Section 26 2726.
3. Use identification label to identify fire alarm system devices.
4. Use identification label to identify serving branch circuit for all receptacles.
a. For receptacles in public areas or in areas as directed by Architect, provide identification on inside surface of wallplate.

2.2 MANUFACTURERS

A. Brady Corporation: www.bradycorp.com.

B. Substitutions: See Section 01 6000 - Product Requirements.

2.3 LARGE DEVICE IDENTIFICATION

A. Identify all disconnect switches, pull boxes, junction boxes (larger than 4" X 4") in unfinished areas with Brady voltage markers, catalog #B-498, series #44xxx (xxx indicates last 3 numbers of model number which vary based on voltage, size, etc. Contractor shall coordinate this information prior to ordering). Sizes for each label shall be as large as possible, style "A", "B" or "C" as the device permits.

B. Identify all disconnect switches, pull boxes, junction boxes (larger than 4" X 4") finished with black engraved lamicoid self-adhesive labels, 1" X 4". The label shall state the power feed, circuit or section number, and the equipment identification number that the large device serves.

2.4 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:
   1. Materials:
   2. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.

B. Identification Labels:
   1. Manufacturers:
      a. Brady Corporation; _____: www.bradyid.com/#sle.
      b. Brother International Corporation: www.brother-usa.com/#sle.
      c. Panduit Corp: www.panduit.com/#sle.
      d. Substitutions: See Section 01 6000 - Product Requirements.
   2. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
      a. Use only for indoor locations.
   3. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

C. Format for Equipment Identification:
   1. Minimum Size: 1 inch by 2.5 inches.
   2. Legend:
      a. Equipment designation or other approved description.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height:
      a. Equipment Designation: 1/2 inch.
   5. Color:
      a. Normal Power System: White text on black background.

D. Format for General Information and Operating Instructions:
   1. Minimum Size: 1 inch by 2.5 inches.
   2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height: 1/4 inch.
   5. Color: Black text on white background unless otherwise indicated.

E. Format for Receptacle Identification:
   1. Minimum Size: 3/8 inch by 1.5 inches.
   2. Legend: Power source and circuit number or other designation indicated.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height: 3/16 inch.
   5. Color: Black text on clear background.

F. Format for Control Device Identification:
   1. Minimum Size: 3/8 inch by 1.5 inches.
   2. Legend: Load controlled or other designation indicated.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height: 3/16 inch.
   5. Color: Black text on clear background.

G. Format for Fire Alarm Device Identification:
   1. Minimum Size: 3/8 inch by 1.5 inches.
   2. Legend: Designation indicated and device zone or address.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height: 3/16 inch.
   5. Color: Red text on white background.

H. Nameplates: Engraved three-layer laminated plastic, black letters on white background, 2" by 6" in size

I. Locations:
   1. Each electrical distribution and control equipment enclosure.
   2. Disconnect Switches
   3. Panelboards.

J. Letter Size:
   1. Use 1/8 inch letters for identifying individual equipment and loads.

K. Labels: Embossed adhesive tape, with 3/16 inch (5 mm) white letters on black background. Use only for identification of individual wall switches and receptacles, and control device stations.

2.5 WIRE AND CABLE MARKERS

A. Manufacturers:

1. Brady, Bradysleeve, Catalog #B-320 PVC.
2. Substitutions: See Section 01 6000 - Product Requirements.

B. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.

C. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.

D. Legend: Power source and circuit number or other designation indicated.

E. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.

F. Minimum Text Height: 1/8 inch.

G. Color: Black text on white background unless otherwise indicated.

H. Locations: Each conductor at pull boxes, junction boxes, and Termination or connection points including each load connection.

I. Legend:
1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.

2.6 VOLTAGE MARKERS

A. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.

B. Minimum Size:
1. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
2. Markers for Junction Boxes: 1/2 by 2 1/4 inches.

C. Legend:
1. Markers for Voltage Identification: Highest voltage present.

D. Color: Black text on orange background unless otherwise indicated.

E. Location: Furnish markers for each conduit longer than 6 feet.

F. Spacing: 20 feet on center.

2.7 WARNING SIGNS AND LABELS

A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.

B. Warning Signs:
1. Materials:
a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.

2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
3. Minimum Size: 7 by 10 inches unless otherwise indicated.

C. Warning Labels:
1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

B. Degrease and clean surfaces to receive nameplates and labels.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
1. Surface-Mounted Equipment: Enclosure front.
2. Flush-Mounted Equipment: Inside of equipment door.
3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
4. Elevated Equipment: Legible from the floor or working platform.
5. Branch Devices: Adjacent to device.
6. Interior Components: Legible from the point of access.
7. Conduits: Legible from the floor.
8. Boxes: Outside face of cover.
9. Conductors and Cables: Legible from the point of access.
10. Devices: Outside face of cover.

C. Install identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.

E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Secure rigid signs using stainless steel screws.

G. Mark all handwritten text, where permitted, to be neat and legible.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

SECTION 26 0573 - POWER SYSTEM STUDIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Arc flash and shock risk assessment.
   1. Includes arc flash hazard warning labels.

B. Criteria for the selection and adjustment of equipment and associated protective devices not specified in this section, as determined by studies to be performed.

C. Flash Hazard Study

1.2 RELATED REQUIREMENTS

A. Section 26 2416 - Panelboards.

B. Section 26 2813 - Fuses.

1.3 REFERENCE STANDARDS

A. NEMA MG 1 - Motors and Generators; 2017.

B. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
   2. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
   1. Submit study reports prior to or concurrent with product submittals.
   2. Do not order equipment until matching study reports and product submittals have both been evaluated by DEDC, LLC.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Study reports, stamped or sealed and signed by study preparer.

C. Certification that field adjustable protective devices have been set in accordance with requirements of studies.

D. Project Record Documents: Revise studies as required to reflect as-built conditions.
   1. Include hard copies with operation and maintenance data submittals.
   2. Include computer software files used to prepare studies with file name(s) cross-referenced to specific pieces of equipment and systems.

1.6 POWER SYSTEM STUDIES

A. Scope of Studies:
   1. Except where study descriptions below indicate exclusions, analyze system at each bus from primary protective devices of utility source down to each piece of equipment involved, including parts of system affecting calculations being performed (e.g. fault current contribution from motors).
   2. Include in analysis alternate sources and operating modes (including known future configurations) to determine worst case conditions.

B. General Study Requirements:
   1. Comply with NFPA 70.
   2. Perform studies utilizing computer software complying with specified requirements; manual calculations are not permitted.

C. Data Collection:
   1. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling.
      a. Utility Source Data: Include primary voltage, maximum and minimum three-phase and line-to-ground fault currents, impedance, X/R ratio, and primary protective device information.
         1) Obtain up-to-date information from Utility Company.
      b. Generators: Include manufacturer/model, kW and voltage ratings, and impedance.
      c. Motors: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 1 code letter designation.
      d. Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio.
      e. Protective Devices:
         1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).
         2) Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).
      f. Protective Relays: Include manufacturer/model, type, settings, current/potential transformer ratio, and associated protective device.
      g. Conductors: Include feeder size, material (e.g. copper, aluminum), insulation type, voltage rating, number per phase, raceway type, and actual length.

D. Study Reports:

1. General Requirements:
    a. Identify date of study and study preparer.
    b. Identify study methodology and software product(s) used.
    c. Identify scope of studies, assumptions made, implications of possible alternate scenarios, and any exclusions from studies.
    d. Identify base used for per unit values.
    e. Include single-line diagram and associated input data used for studies; identify buses on single-line diagram as referenced in reports, and indicate bus voltage.
    f. Include conclusions and recommendations.

1.7 PROTECTIVE DEVICE STUDY

A. Flash Hazard Study: Contractor responsible to calculate flash hazard, shock values, and required Personal Protecction Device (PPE) requirements in accordance with OSHA Standards. Study must be continuted until OSHA defined 'Level-0' protection is achieved. Contractor is also responsible to provide the following:
    1. Furnish Flash / Shock / and PPE labels as calculated by study. Coordinate with electrical contractor for installation of labels on all equipment.

1.8 QUALITY ASSURANCE

A. Study Preparer Qualifications: Professional electrical engineer licensed in Maryland and with minimum five years experience in the preparation of studies of similar type and complexity using specified computer software.

B. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
    1. Acceptable Software Products:
        a. SKM Systems Analysis, Inc: www.skm.com/#sle.

PART 2 PRODUCTS

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Adjust equipment and protective devices for compliance with studies and recommended settings.

D. Notify DEDC, LLC of any conflicts with or deviations from studies. Obtain direction before proceeding.

END OF SECTION

SECTION 26 0583 - WIRING CONNECTIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical connections to equipment.

1.2 RELATED REQUIREMENTS

A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.

B. Section 26 0533.13 - Conduit for Electrical Systems.

C. Section 26 0533.16 - Boxes for Electrical Systems.

D. Section 26 2726 - Wiring Devices.

E. Section 26 2816.16 - Enclosed Switches.

1.3 REFERENCE STANDARDS

A. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2015).

B. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2016.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
   2. Determine connection locations and requirements.

B. Sequencing:
   1. Install rough-in of electrical connections before installation of equipment is required.
   2. Make electrical connections before required start-up of equipment.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide wiring device manufacturer’s catalog information showing dimensions, configurations, and construction.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.1 MATERIALS

A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
   1. Colors: Comply with NEMA WD 1.
   2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
   3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

B. Disconnect Switches: As specified in Section 26 2816.16 and in individual equipment sections.

C. Wiring Devices: As specified in Section 26 2726.

D. Flexible Conduit: As specified in Section 26 0533.13.

E. Wire and Cable: As specified in Section 26 0519.

F. Boxes: As specified in Section 26 0533.16.

2.2 EQUIPMENT CONNECTIONS

A. VRF UNITS

B. Make-Up Air Units

C. Kitchen Exhaust Hoods

D. Kitchen Exhaust Fans

E. NO/CO systems

F. Electric Hot Water heaters

G. All electrical systems

H. All mechanical equipment stand-alone control equipment

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.

C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

D. Provide receptacle outlet to accommodate connection with attachment plug.

E. Provide cord and cap where field-supplied attachment plug is required.

F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

H. Install terminal block jumpers to complete equipment wiring requirements.

I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

END OF SECTION

SECTION 26 0923 - DISTRIBUTED DIGITAL LIGHTING CONTROL SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Digital Lighting Controls
   2. Related Sections:
      a. Section [265100 - Interior Lighting] Luminaires
      b. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section
      c. Electrical Sections, including wiring devices, apply to the work of this Section.
   3. Control Intent – Control Intent includes, but is not limited to:
      a. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
      b. Initial sensor and switching zones
      c. Initial time switch settings

1.2 REFERENCES

A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) (www.ansi.org <http://www.ansi.org> and www.ieee.org)

B. International Electrotechnical Commission (IEC) (www.iec.ch <http://www.iec.ch>)

C. International Organization for Standardization (ISO) (www.iso.ch <http://www.iso.ch>):

D. National Electrical Manufacturers Association (NEMA) (www.nema.org <http://www.nema.org>)

E. WD1 (R2005) - General Color Requirements for Wiring Devices.

F. Underwriters Laboratories, Inc. (UL) (www.ul.com <http://www.ul.com>):
   1. 916 – Energy Management Equipment

1.3 SYSTEM DESCRIPTION & OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:
   1. Lighting Management local network – Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.
   2. Digital Room Controllers – Self-configuring, digitally addressable one, two or three relay plenum-rated controllers for on/off control. Selected models include 0-10 volt or line voltage forward phase control dimming outputs and integral current monitoring capabilities.
   3. Digital Fixture Controllers – Self-configuring, digitally addressable one relay fixture-integrated controllers for on/off/0-10V dimming control.
   4. Digital Occupancy Sensors – Self-configuring, digitally addressable, calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.

5. Digital Switches – Self-configuring, digitally addressable pushbutton on/off, dimming, and scene switches with two-way active infrared (IR) communications.
6. Digital Daylighting Sensors – Single-zone closed loop, multi-zone open loop and single-zone dual-loop daylighting sensors with two-way active infrared (IR) communications for daylight harvesting using switching, bi-level, tri-level or dimming control.
7. Configuration Tools – Handheld remote for room configuration and relay panel programming provides two way infrared (IR) communications to digital devices and allows complete configuration and reconfiguration of the device / room from up to 30 feet away.

1.4 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local energy codes are more stringent, provide a minimum application of lighting controls as follows:
   1. Space Control Requirements – Provide occupancy/vacancy sensors with Manual- or Partial-ON functionality in all spaces as shown on plan drawings.
   2. Daylit Areas – Provide daylight-responsive automatic control in all spaces (conditioned or unconditioned) where daylight contribution is available as defined by relevant local building energy code:
      a. Daytime setpoints for total ambient illumination (combined daylight and electric light) levels that initiate dimming shall be programmed in compliance with relevant local building energy codes.
      b. Multiple-level switched daylight harvesting controls may be utilized for areas marked on drawings.
      c. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylighting control system may be designed to turn off electric lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.
      d. Conference, meeting, training, auditoriums, and multipurpose rooms shall have controls that allow for independent control of each local control zone. Rooms larger than 300 square feet shall instead have at least four preset lighting scenes unless otherwise specified. Occupancy / vacancy sensors shall be provided to turn off all lighting in the space. Spaces with up to four moveable walls shall include controls that can be reconfigured when the room is partitioned.

1.5 SUBMITTALS

A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.

B. Shop Drawings:
   1. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed.
   2. Show exact location of all digital devices, including at minimum sensors, load controllers, and switches for each area on reflected ceiling plans. (Contractor must provide AutoCAD format reflected ceiling plans.)
   3. Provide room/area details including products and sequence of operation for each room or area. Illustrate typical acceptable room/area connection topologies.
   4. Product Data: Catalog sheets, specifications and installation instructions.

1.6 QUALITY ASSURANCE

1.7 MANUFACTURER: MINIMUM 10 YEARS EXPERIENCE IN MANUFACTURE OF LIGHTING CONTROLS.

1.8 PROJECT CONDITIONS

A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
   1. Ambient temperature: 0° to 40° C (32° to 104° F).
   2. Relative humidity: Maximum 90 percent, non-condensing.

1.9 WARRANTY

A. Provide a five year limited manufacturer's warranty on all room control devices and panels.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer:
   1. WattStopper
      a. System: Digital Lighting Management
   2. Or approved equal

2.2 DIGITAL LIGHTING CONTROLS

A. Furnish the Company's system which accommodates the square-footage coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors, switches, daylighting sensors and accessories which suit the lighting and electrical system parameters.

2.3 LOCAL NETWORK (ROOM NETWORK)

A. The local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building.

B. Features of the local network include:
   1. Plug n' Go™ automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
   2. Simple replacement of any device in the local network with a standard off the shelf unit without requiring significant commissioning, configuration or setup.
   3. Push n' Learn™ configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
   4. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.
   5. Digital room devices connect to the local network using pre-terminated Cat 5e cables with RJ-45 connectors, which provide both data and power to room devices. Systems that utilize RJ-45 patch cords but do not provide serial communication data from individual end devices are not acceptable.

6. If manufacturer's pre-terminated Cat5e cables are not used for the installation, the contractor is responsible for testing each cable following installation and supplying manufacturer with test results.

2.4 DIGITAL LOAD CONTROLLERS (ROOM AND FIXTURE CONTROLLERS)

A. Digital controllers for lighting loads automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room load controllers shall be provided to match the room lighting load control requirements. The controllers will be simple to install, and will not have dip switches or potentiometers, or require special configuration for standard Plug n' Go applications. The control units will include the following features:
   1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
   2. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.
   3. Multiple room controllers connected together in a local network must automatically arbitrate with each other, without requiring any configuration or setup, so that individual load numbers are sequentially assigned using each controller's device ID's from highest to lowest.
   4. Device Status LEDs to indicate:
      a. Device has power
      b. Quick installation features including:
         1) Standard junction box mounting
         2) Quick low voltage connections using standard RJ-45 patch cable
      c. Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:
         1) Turn on to 100%
         2) Turn off
         3) Turn on to last level
      d. Each load shall at a minimum be configurable to operate in the following sequences based on occupancy:
         1) Auto-on/Auto-off (Follow on and off)
         2) Manual-on/Auto-off (Follow off only)
      e. The polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.
      f. UL 2043 plenum rated
      g. Manual override and LED indication for each load
      h. Dual voltage (120/277 VAC, 60 Hz), or 347 VAC, 60 Hz (selected models only). 120/277 volt models rated for 20A total load, derating to 16A required for some dimmed loads (forward phase dimming); 347 volt models rated for 15A total load.
      i. Zero cross circuitry for each load
      j. All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.
   5. On/Off Room Controllers shall include:
      a. One, two or three relay configuration
      b. Efficient 150 mA switching power supply

c. Three RJ-45 local network ports with integral strain relief and dust cover

6. On/Off/Dimming enhanced Room Controllers shall include:
   a. Real time current monitoring
   b. Multiple relay configurations
      1) One, two or three relays
   c. Efficient 250 mA switching power supply
   d. Four RJ-45 Lighting Management local network ports with integral strain relief and dust cover
   e. One dimming output per relay
      1) 0-10V Dimming - Where indicated, one 0-10 volt analog output per relay for control of compatible ballasts and LED drivers. The 0-10 volt output shall automatically open upon loss of power to the Room Controller to assure full light output from the controlled lighting.
      2) Line Voltage, Forward Phase Dimming - Where indicated, one forward phase control line voltage dimming output per relay for control of compatible two-wire or three-wire ballasts, LED drivers, MLV, forward phase compatible ELV, neon/cold cathode and incandescent loads.
      3) Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected ballast or driver.
      4) The LED level indicators on bound dimming switches shall utilize this new maximum and minimum trim.
      5) Each dimming output channel shall have an independently configurable minimum and maximum trim level to set the dynamic range of the output within the new 0-100% dimming range defined by the minimum and maximum calibration trim.
      6) Calibration and trim levels must be set per output channel.
      7) Devices that set calibration or trim levels per controller are not acceptable.
      8) All configuration shall be digital. Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.
   f. Each load shall have an independently configurable preset on level for Normal Hours and After Hours events to allow different dimmed levels to be established at the start of both Normal Hours and After Hours events.
   g. Fade rates for dimming loads shall be specific to bound switch buttons, and the load shall maintain a default value for any bound buttons that do not specify a unique value.
   h. The following dimming attributes may be changed or selected using a wireless configuration tool:
      1) Establish preset level for each load from 0-100%
      2) Set high and low trim for each load
      3) Set lamp burn in time for each load up to 100 hours
   i. Override button for each load provides the following functions:
      1) Press and release for on/off control
      2) Press and hold for dimming control
7. Fixture Controllers shall include:
   a. A form factor and product ratings to allow various OEM fixture manufacturers to mount the device inside the ballast/driver cavity of standard-sized fluorescent or LED general lighting fixtures.

b. One 3A 120/277V rated mechanically held relay.
c. Programmable behavior on power up following the loss of normal power:
    1) Turn on to 100%
    2) Turn off
    3) Turn on to last level
d. Requirement for 7 mA of 24VDC operating power from the DLM local network.
    1) The Fixture Controller does not require a connection to a neutral conductor to operate, and unlike other types of Load Controllers it does not contribute power to the Lighting Management local network to drive accessory devices.
e. 0-10V dimming capability via a single 0-10 volt analog output from the device for control of compatible ballasts and LED drivers. The 0-10 volt output shall automatically open upon loss of power to the Fixture Controller.
f. Terminals to connect an RJ-45 adaptor with 24" leads, mountable in a ½" KO, for connection to the Lighting Management local network.
    1) The adaptor leads are insulated for use in a fixture cavity, and the lead length allows the OEM fixture manufacturer flexibility to position the Fixture Controller and the RJ45 jack in the best locations on each fixture.
g. A complete set of dimming features described above in the section detailing On/Off/Dimming Enhanced Room Controllers (subsection C.5 onward).

2.5 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR

A. Wall or ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor.

B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
    1. Digital calibration and pushbutton configuration for the following variables:
        a. Sensitivity – 0-100% in 10% increments
        b. Time delay – 1-30 minutes in 1 minute increments
        c. Test mode – Five second time delay
        d. Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
        e. Walk-through mode
        f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
        g. Programmable control functionality including:
            1) Each sensor may be programmed to control specific loads within a local network.
            2) Sensor shall be capable of activating one of 16 user-definable lighting scenes.
            3) Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically within a configurable period of time (default 10 seconds) after turning off.
            4) On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
            5) Ultrasonic and Passive Infrared
            6) Ultrasonic or Passive Infrared
            7) Ultrasonic only

8) Passive Infrared only
9) Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.

h. One or two RJ-45 port(s) for connection to Lighting Management local network.
i. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
j. Device Status LEDs, which may be disabled for selected applications, including:
1) PIR detection
2) Ultrasonic detection
3) Configuration mode
4) Load binding
k. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
l. Manual override of controlled loads.
m. All digital parameter data programmed into an individual occupancy sensor shall be retained in non-volatile FLASH memory within the sensor itself. Memory shall have an expected life of no less than 10 years.

2. Units shall not have any dip switches or potentiometers for field settings.
3. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology lighting management local network. No additional configuration will be required.

2.6 DIGITAL WALL SWITCH OCCUPANCY SENSORS

A. Wallbox mounted passive infrared PIR or dual technology (passive infrared and ultrasonic) digital occupancy sensor with 1 or 2 switch buttons.

B. Digital Occupancy Sensors shall provide scrolling LCD display for digital calibration and electronic documentation. Features include the following:
1. Digital calibration and pushbutton configuration for the following variables:
a. Sensitivity – 0-100% in 10% increments
b. Time delay – 1-30 minutes in 1 minute increments
c. Test mode – Five second time delay
d. Detection technology – PIR, Dual Technology activation and/or re-activation.
e. Walk-through mode
f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
g. Programmable control functionality including:
1) Each sensor may be programmed to control specific loads within a local network.
2) Sensor shall be capable of activating one of 16 user-definable lighting scenes.
3) Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically during the configurable period of time (default 10 seconds) after turning off.
4) On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
(a) Ultrasonic and Passive Infrared

(b) Ultrasonic or Passive Infrared
(c) Ultrasonic only
(d) Passive Infrared only

h. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.
i. Two RJ-45 ports for connection to Lighting Management local network.
j. Two-way infrared (IR) transceiver to allow remote programming through handheld configuration tool and control by remote personal controls.
k. Device Status LEDs including
   1) PIR detection
   2) Ultrasonic detection
   3) Configuration mode
   4) Load binding
l. Assignment of any occupancy sensor to a specific load within the room without wiring or special tools.
m. Assignment of local buttons to specific loads within the room without wiring or special tools
n. Manual override of controlled loads
o. All digital parameter data programmed into an individual wall switch sensor shall be retained in non-volatile FLASH memory within the wall switch sensor itself. Memory shall have an expected life of no less than 10 years.

2. Units shall not have any dip switches or potentiometers for field settings.
3. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology lightning management local network. No additional configuration will be required.
4. Two-button wall switch occupancy sensors, when connected to a single relay dimming room or fixture controller, shall operate in the following sequence as a factory default:
   a. Left button
      1) Press and release - Turn load on
      2) Press and hold - Raise dimming load
   b. Right button
      1) Press and release - Turn load off
      2) Press and hold - Lower dimming load
5. Low voltage momentary pushbuttons shall include the following features:
   a. Load/Scene Status LED on each switch button with the following characteristics:
      1) Bi-level LED
      2) Dim locator level indicates power to switch
      3) Bright status level indicates that load or scene is active
   b. The following button attributes may be changed or selected using a wireless configuration tool:
      1) Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
      2) Individual button function may be configured to Toggle, On only or Off only.
      3) Individual scenes may be locked to prevent unauthorized change.
      4) Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
      5) Ramp rate may be adjusted for each dimmer switch.

6) Switch buttons may be bound to any load on any load controller or relay panel and are not load type dependent; each button may be bound to multiple loads.

2.7 DIGITAL WALL SWITCHES

A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration. Wall switches shall include the following features:
   1. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
   2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
   3. Configuration LED on each switch that blinks to indicate data transmission.
   4. Load/Scene Status LED on each switch button with the following characteristics:
      a. Bi-level LED
      b. Dim locator level indicates power to switch
      c. Bright status level indicates that load or scene is active
      d. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
      e. Programmable control functionality including:
         1) Button priority may be configured to any BACnet priority level, from 1-16, corresponding to networked operation allowing local actions to utilize life safety priority
         2) Scene patterns may be saved to any button other than dimming rockers. Once set, buttons may be digitally locked to prevent overwriting of the preset levels.
      f. All digital parameter data programmed into an individual wall switch shall be retained in non-volatile FLASH memory within the wall switch itself. Memory shall have an expected life of no less than 10 years.
   5. Two RJ-45 ports for connection to Lighting Management local network.
   6. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology lighting management local network. No additional configuration shall be required to achieve multi-way switching.
   7. The following switch attributes may be changed or selected using a wireless configuration tool:
   8. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
      a. Individual button function may be configured to Toggle, On only or Off only.
      b. Individual scenes may be locked to prevent unauthorized change.
      c. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
      d. Ramp rate may be adjusted for each dimmer switch.
      e. Switch buttons may be bound to any load on any load controller or relay panel and are not load type dependant; each button may be bound to multiple loads.

2.8 DIGITAL DAYLIGHTING SENSORS

A. Digital daylighting sensors shall work with load controllers and relay panels to provide automatic switching, bi-level, or tri-level or dimming daylight harvesting capabilities for any load type connected to the controller or panel. Daylighting sensors shall be interchangeable without the need for rewiring.
   1. Closed loop sensors measure the ambient light in the space and control a single lighting zone.

2. Open loop sensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones.
3. Dual loop sensors measure both ambient and incoming daylight in the space to insure that proper light levels are maintained as changes to reflective materials are made in a single zone.
4. Digital daylighting sensors shall include the following features:
    a. The sensor's internal photodiode shall only measure lightwaves within the visible spectrum. The photodiode's spectral response curve shall closely match the entire photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.
    b. Sensor light level range shall be from 1-6,553 footcandles (fc).
    c. The capability of ON/OFF, bi-level or tri-level switching, or dimming, for each controlled zone, depending on the selection of load controller(s) and load binding to controller(s).
    d. For switching daylight harvesting, the photosensor shall provide a field-selectable deadband, or a separation, between the "ON Setpoint" and the "OFF Setpoint" that will prevent the lights from cycling excessively after they turn off.
    e. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a field-selectable minimum level.
    f. Photosensors shall have a digital, independently configurable fade rate for both increasing and decreasing light level in units of percent per second.
    g. Photosensors shall provide adjustable cut-off time. Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns off. Selectable range between 0-240 minutes including option to never cut-off.
    h. Optional wall switch override shall allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise lighting levels for a selectable period of time or cycle of occupancy.
    i. Integral infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
    j. Configuration LED status light on device that blinks to indicate data transmission.
    k. Status LED indicates test mode, override mode and load binding.
    l. Recessed switch on device to turn controlled load(s) ON and OFF.
    m. One RJ-45 port for connection to DLM local network.
    n. A choice of accessories to accommodate multiple mounting methods and building materials. The photosensors may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox. Standard tube photosensors accommodate mounting materials from 0-0.62" thickness. Extended tube photosensors accommodate mounting materials from 0.62"-1.25" thickness. Mounting brackets are compatible with J boxes and wall mounting. Photosensor to be mounted on included bracket below skylight well.
    o. Any load or group of loads in the room can be assigned to a daylighting zone
    p. Each load within a daylighting zone can be individually enabled or disabled for discrete control (load independence).
    q. All digital parameter data programmed into a photosensor shall be retained in non-volatile FLASH memory within the photosensor itself. Memory shall have an expected life of no less than 10 years.

5. Closed loop digital photosensors shall include the following additional features:
    a. An internal photodiode that measures light in a 100-degree angle, cutting off the unwanted light from bright sources outside of this cone.
    b. Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
    c. Automatically establishes application-specific setpoints following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of loads.
6. Open loop digital photosensors shall include the following additional features:
    a. An internal photodiode that measures light in a 60-degree angle (cutting off the unwanted light from the interior of the room).
    b. Automatically establishes application-specific setpoints following manual calibration using a wireless configuration tool or a PC with appropriate software. For switching operation, an adequate deadband between the ON and OFF setpoints for each zone shall prevent the lights from cycling; for dimming operation, a proportional control algorithm shall maintain the design lighting level in each zone.
    c. Each of the three discrete daylight zones can include any non overlapping group of loads in the room.
7. Dual loop digital photosensors shall include the following additional features:
    a. Close loop portion of dual loop device must have an internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from sources outside of this con
    b. Open loop portion of dual loop device must have an internal photodiode that can measure light in a 60 degree angle, cutting off the unwanted light from the interior of the room.
    c. Automatically establishes application-specific set-points following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of load.
    d. Device must reference closed loop photosensor information as a base line reference. The device must be able to analyze the open loop photosensor information to determine if an adjustment in light levels is required.
    e. Device must be able to automatically commission setpoints each night to provide adjustments to electrical lighting based on changes in overall lighting in the space due to changes in reflectance within the space or changes to daylight contribution based on seasonal changes.
    f. Device must include extendable mounting arm to properly position sensor within a skylight well.

2.9 HANDHELD AND COMPUTER CONFIGURATION TOOLS

A. A wireless configuration tool facilitates optional customization of lighting management local networks using two-way infrared communications, while PC software connects to each local network via a USB interface.

B. Features and functionality of the wireless configuration tool shall include but not be limited to:
    1. Two-way infrared (IR) communication with lighting management IR-enabled devices within a range of approximately 30 feet.

2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
3. Must be able to read and modify parameters for load controllers and relay panels, occupancy sensors, wall switches, daylighting sensors, network bridges, and identify Lighting Management devices by type and serial number.
4. Save up to eight occupancy sensor setting profiles, and apply profiles to selected sensors.
5. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
6. Adjust or fine-tune daylighting settings established during auto-configuration, and input light level data to complete configuration of open loop daylighting controls.
7. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
8. Verify status of building level network devices.

PART 3 EXECUTION

3.1 PRE-INSTALLATION MEETING

A. A factory authorized manufacturer's representative shall provide the electrical contractor a functional overview of the lighting control system prior to installation. The contractor shall schedule the pre-installation site visit after receipt of approved submittals to review the following:
   1. Confirm the location and mounting of all digital devices, with special attention to placement of occupancy and daylighting sensors.
   2. Review the specifications for low voltage control wiring and termination.
   3. Discuss the functionality and configuration of all products, including sequences of operation, per design requirements.
   4. Discuss requirements for integration with other trades.

3.2 CONTRACTOR INSTALLATION AND SERVICES

A. Contractor to install all devices and wiring in a professional manner. All line voltage connections to be tagged to indicate circuit and switched legs.

B. Contractor to install all room/area devices using manufacturer's factory-tested Cat 5e cable with pre-terminated RJ-45 connectors. If pre-terminated cable is not used for room/area wiring, the contractor is responsible for testing each field-terminated cable following installation, and shall supply the lighting controls manufactuerer with test results.

C. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated. Before start up, contractor shall test all devices to ensure proper communication.

D. Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.
   1. Adjust time delay so that controlled area remains lighted while occupied.
   2. Provide written or computer-generated documentation on the configuration of the system including room by room description including:
      a. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
      b. Sequence of operation, (e.g. manual ON, Auto OFF. etc.)

c. Load Parameters (e.g. blink warning, etc.)

3. Post start-up tuning – After 30 days from occupancy contractor shall adjust sensor time delays and sensitivities to meet the Owner's requirements. Provide a detailed report to the Architect / Owner of post start-up activity.

3.3 FACTORY SERVICES

A. Upon completion of the installation, the manufacturer's factory authorized representative shall start up and verify a complete fully functional system.

B. Upon completion of the system start up, the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

3.4 COMMISSIONING SUPPORT SERVICES

A. On this project, a commissioning agent will be hired to verify the installation and programming of all building systems, which includes the lighting control system. Manufacturer should include an extra day of technician's time to review the functionality and settings of the lighting control hardware with the commissioning agent, including reviewing submittal drawings and ensuring that instructions on how to configure each device are readily available. Manufacturer is NOT responsible for helping the commissioning agent inspect the individual devices. It will be the commissioning agent's responsibility to create and complete any forms required for the commissioning process, although the manufacturer or contractor may offer spreadsheets and/or printouts to assist the agent with this task.

B. The commissioning agent shall work with the electrical contractor during installation of the lighting control hardware to become familiar with the specific products. The agent may also accompany the manufacturer's technicians during their start-up work to better understand the process of testing, calibration and configuration of the products. However, the contractor and manufacturer shall ensure that interfacing with the agent does not prevent them from completing the requirements outlined in the contract documents.

END OF SECTION

SECTION 26 2100 - LOW-VOLTAGE ELECTRICAL SERVICE ENTRANCE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical service requirements.

1.2 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Materials and installation requirements for cast-in-place concrete equipment pads.

B. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.

C. Section 26 0526 - Grounding and Bonding for Electrical Systems.

D. Section 26 0529 - Hangers and Supports for Electrical Systems.

E. Section 26 0533.13 - Conduit for Electrical Systems.

F. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

G. Section 26 2416 - Panelboards: Service entrance equipment.

H. Section 26 2816.16 - Enclosed Switches: Service entrance equipment.

I. Section 26 3213 - Engine Generators: Emergency/standby power systems for interconnection with normal utility electrical supply.

J. Section 26 3600 - Transfer Switches: Service entrance equipment.

K. Section 26 4300 - Surge Protective Devices: Service entrance surge protective devices.

L. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.

1.3 DEFINITIONS

A. Service Point: The point of connection between the facilities of the serving utility and the premises wiring as defined in NFPA 70, and as designated by the Utility Company.

1.4 REFERENCE STANDARDS

A. IEEE C2 - National Electrical Safety Code; 2017.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 ADMINISTRATIVE REQUIREMENTS

A. No later than two weeks following date of the Agreement, notify Utility Company of anticipated date of service.

B. Coordination:
   1. Verify the following with Utility Company representative:
      a. Utility Company requirements, including division of responsibility.
      b. Exact location and details of utility point of connection.
      c. Utility easement requirements.
      d. Utility Company charges associated with providing service.
   2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for electrical service and associated equipment.
   3. Coordinate arrangement of service entrance equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   4. Coordinate the work with other installers to provide communication lines required for Utility Company meters.
   5. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

C. Arrange for Utility Company to provide temporary and permanent electrical service. Prepare and submit documentation required by Utility Company.

D. Utility Company charges associated with providing temporary and permanent service to be paid by Contractor..

E. Preinstallation Meeting: Convene one month prior to commencing work of this section to review service requirements and details with Utility Company representative.

F. Scheduling:
   1. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.
   2. Arrange for inspections necessary to obtain Utility Company approval of installation.

1.6 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product. Include ratings, configurations, standard wiring diagrams, outline and support point dimensions, finishes, weights, service condition requirements, and installed features.

C. Shop Drawings: Include dimensioned plan views and sections indicating locations and arrangement of Utility Company and service entrance equipment, metering provisions, required clearances, and proposed service routing.
   1. Obtain Utility company approval of shop drawings prior to submittal.

D. Drawings prepared by Utility Company.

E. Project Record Documents: Record actual locations of equipment and installed service routing.

1.7 QUALITY ASSURANCE

A. Comply with the following:
   1. IEEE C2 (National Electrical Safety Code).
   2. NFPA 70 (National Electrical Code).
   3. The requirements of the Utility Company.
   4. The requirements of the local authorities having jurisdiction.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

B. Store products indoors in a clean, dry space having a uniform temperature to prevent condensation (including outdoor rated products which are not weatherproof until completely and properly installed). Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle products carefully to avoid damage to internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 ELECTRICAL SERVICE REQUIREMENTS

A. Provide new electrical service consisting of all required conduits, conductors, equipment, metering provisions, supports, accessories, etc. as necessary for connection between Utility Company point of supply and service entrance equipment.

B. Electrical Service Characteristics:
   1. Service Type: as indicated on drawings.
   2. Service Voltage: as indicated on drawings.
   3. Service Size: as indicated on drawings.

C. Utility Company: Balltimore Gas and Electric.

D. Division of Responsibility: As indicated on drawings.

E. Products Furnished by Contractor: Comply with Utility Company requirements.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that ratings and configurations of service entrance equipment are consistent with the indicated requirements.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Verify and mark locations of existing underground utilities.

3.3 INSTALLATION

A. Install products in accordance with manufacturer's instructions and Utility Company requirements.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances and required maintenance access.

D. Provide required trenching and backfilling in accordance with Section 31 2316.13.

E. Construct cast-in-place concrete pads for utility equipment in accordance with Utility Company requirements and Section 03 3000.

F. Provide required protective bollards in accordance with Utility Company requirements.

G. Provide required support and attachment components in accordance with Section 26 0529.

H. Provide grounding and bonding for service entrance equipment in accordance with Section 26 0526.

I. Identify service entrance equipment, including main service disconnect(s) in accordance with Section 26 0553.

3.4 PROTECTION

A. Protect installed equipment from subsequent construction operations.

END OF SECTION

SECTION 26 2413 - SWITCHBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Low-voltage (600 V and less) switchboards and associated accessories for service and distribution applications.

B. Overcurrent protective devices for switchboards.

1.2 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.

B. Section 26 0526 - Grounding and Bonding for Electrical Systems.

C. Section 26 0529 - Hangers and Supports for Electrical Systems.

D. Section 26 0548 - Vibration and Seismic Controls for Electrical Systems.
   1. Includes requirements for the seismic qualification of equipment specified in this section.

E. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

F. Section 26 0573 - Power System Studies: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.

G. Section 26 2100 - Low-Voltage Electrical Service Entrance.

H. Section 26 4300 - Surge Protective Devices.

1.3 REFERENCE STANDARDS

A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; 2013e (Amended 2017).

B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers; 2016.

C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

D. NECA 400 - Standard for Installing and Maintaining Switchboards; 2007.

E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2018.

F. NEMA PB 2 - Deadfront Distribution Switchboards; 2011.

G. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less; 2013.

H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

I. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

K. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.

L. UL 891 - Switchboards; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   4. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
   5. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Service Entrance Switchboards:
   1. Coordinate with Utility Company to provide switchboards with suitable provisions for electrical service and utility metering, where applicable.
   2. Coordinate with Owner to arrange for Utility Company required access to equipment for installation and maintenance.
   3. Obtain Utility Company approval of switchboard prior to fabrication.
   4. Arrange for inspections necessary to obtain Utility Company approval of installation.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.

C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
   1. Include dimensioned plan and elevation views of switchboards and adjacent equipment with all required clearances indicated.
   2. Identify mounting conditions required for equipment seismic qualification.

D. Manufacturer's equipment seismic qualification certification.

E. Field Quality Control Test Reports.

F. Project Record Documents: Record actual installed locations of switchboards and final equipment settings.

G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Enclosure Keys: Two of each different key.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.

B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.

C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

A. Maintain field conditions within required service conditions during and after installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Switchboards - Other Acceptable Manufacturers:
   1. Eaton Corporation; _____: www.eaton.com/#sle.

2. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.

B. Substitutions: See Section 01 6000 - Product Requirements.

C. Source Limitations: Furnish switchboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 SWITCHBOARDS

A. Provide switchboards consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.

D. Service Entrance Switchboards:
1. Listed and labeled as suitable for use as service equipment according to UL 869A.
2. For solidly-grounded wye systems, provide factory-installed main bonding jumper between neutral and ground busses, and removable neutral disconnecting link for testing purposes.
3. Comply with Utility Company requirements for electrical service.
4. See Section 26 2100 for additional requirements.

E. Seismic Qualification: Provide switchboards and associated components suitable for application under the seismic design criteria specified in Section 26 0548 where required. Include certification of compliance with submittals.

F. Service Conditions:
1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
a. Altitude: Less than 6,600 feet.
b. Ambient Temperature:
1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.

G. Short Circuit Current Rating:
1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
2. Label equipment utilizing series ratings as required by NFPA 70.

H. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

I. Main Devices: Configure for top or bottom incoming feed as indicated or as required for the installation. Provide separate pull section and/or top-mounted pullbox as indicated or as required to facilitate installation of incoming feed.

J. Bussing: Sized in accordance with UL 891 temperature rise requirements.
   1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
   2. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
   3. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
   4. Phase and Neutral Bus Material: Aluminum.
   5. Ground Bus Material: Aluminum.

K. Conductor Terminations: Suitable for use with the conductors to be installed.
   1. Line Conductor Terminations:
      a. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
      b. Main and Neutral Lug Type: Mechanical.
   2. Load Conductor Terminations:
      a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
      b. Lug Type:

L. Enclosures:
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1 or Type 2 (drip-proof).
   2. Finish: Manufacturer's standard unless otherwise indicated.

M. Future Provisions:
   1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
   2. Equip distribution sections with full height vertical bussing to accommodate maximum utilization of space for devices.

N. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 4300, list switchboards as a complete assembly including surge protective device.

O. Arc Flash Energy-Reducing Maintenance Switching: For circuit breakers rated 1200 A or higher, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.

P. Instrument Transformers:
   1. Comply with IEEE C57.13.
   2. Select suitable ratio, burden, and accuracy as required for connected devices.

3. Current Transformers: Connect secondaries to shorting terminal blocks.
4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

Q. Description: NEMA PB 2 switchboard with electrical ratings and configurations as indicated and specified.

R. Ratings:

S. Main Section Devices: Panel mounted.

T. Distribution Section Devices: Panel mounted.

U. Bus Material: Copper, standard size.

V. Pull Section:

W. Enclosure: Type 1 - General Purpose.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Circuit Breakers:
1. Interrupting Capacity:
a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
2. Molded Case Circuit Breakers:
a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
1) Provide thermal magnetic circuit breakers unless otherwise indicated.
2) Provide electronic trip circuit breakers where indicated.
b. Minimum Interrupting Capacity:
1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
c. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
d. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
1) Provide the following field-adjustable trip response settings:
(a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
(b) Long time delay.
(c) Short time pickup and delay.
(d) Instantaneous pickup.
e. Provide the following circuit breaker types where indicated:

1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.

2.4 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
   1. Dielectric tests.
   2. Mechanical operation tests.
   3. Grounding of instrument transformer cases test.
   4. Electrical operation and control wiring tests, including polarity and sequence tests.
   5. Ground-fault sensing equipment test.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive switchboards.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.

C. Arrange equipment to provide required clearances and maintenance access, including accommodations for any drawout devices.

D. Where switchboard is indicated to be mounted with inaccessible side against wall, provide minimum clearance of 1/2 inch between switchboard and wall.

E. Provide required support and attachment in accordance with Section 26 0529.

F. Provide required seismic controls in accordance with Section 26 0548.

G. Install switchboards plumb and level.

H. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with Section 03 3000.

I. Provide grounding and bonding in accordance with Section 26 0526.

J. Install all field-installed devices, components, and accessories.

K. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

L. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 0573.

M. Provide filler plates to cover unused spaces in switchboards.

N. Identify switchboards in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.

C. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.

D. Inspect and test in accordance with NETA ATS, except Section 4.

E. Perform inspections and tests listed in NETA ATS, Section 7.1.

F. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than _____ amperes. Tests listed as optional are not required.
   1. Perform insulation-resistance tests on all control wiring with respect to ground.
   2. Test functions of the trip unit by means of secondary injection.

G. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.

H. Test shunt trips to verify proper operation.

I. Correct deficiencies and replace damaged or defective switchboards or associated components.

J. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of switchboard covers and doors.

3.5 CLEANING

A. Clean dirt and debris from switchboard enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred surfaces to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

A. See Section 01 7800 - Closeout Submittals, for closeout submittals.

B. See Section 01 7900 - Demonstration and Training, for additional requirements.

C. Training: Train Owner's personnel on operation, adjustment, and maintenance of switchboard and associated devices.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.

3.7 PROTECTION

A. Protect installed switchboards from subsequent construction operations.

END OF SECTION

SECTION 26 2416 - PANELBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Power distribution panelboards.

B. Lighting and appliance panelboards.

C. Overcurrent protective devices for panelboards.

1.2 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.

B. Section 26 0526 - Grounding and Bonding for Electrical Systems.

C. Section 26 0529 - Hangers and Supports for Electrical Systems.

D. Section 26 0548 - Vibration and Seismic Controls for Electrical Systems.
   1. Includes requirements for the seismic qualification of equipment specified in this section.

E. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

F. Section 26 2813 - Fuses: Fuses for fusible switches and spare fuse cabinets.

1.3 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

B. NECA 407 - Standard for Installing and Maintaining Panelboards; 2015.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2018.

D. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

E. NEMA PB 1 - Panelboards; 2011.

F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; 2013.

G. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

K. UL 67 - Panelboards; Current Edition, Including All Revisions.

L. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.

M. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   4. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.

C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
   1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
   2. Include documentation of listed series ratings upon request.
   3. Identify mounting conditions required for equipment seismic qualification.

D. Manufacturer's equipment seismic qualification certification.

E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

A. Maintain ambient temperature within the following limits during and after installation of panelboards:

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Eaton Corporation; _____: www.eaton.com/#sle.

B. Schneider Electric; Square D Products; _____: www.schneider-electric.us/#sle.

C. Substitutions: See Section 01 6000 - Product Requirements.

D. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 PANELBOARDS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Seismic Qualification: Provide panelboards and associated components suitable for application under the seismic design criteria specified in Section 26 0548 where required. Include certification of compliance with submittals.

C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature:

D. Short Circuit Current Rating:
   1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

2. Listed series ratings are acceptable, except where not permitted by motor contribution according to NFPA 70.
3. Label equipment utilizing series ratings as required by NFPA 70.

E. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.

F. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

G. Bussing: Sized in accordance with UL 67 temperature rise requirements.
1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.

H. Conductor Terminations: Suitable for use with the conductors to be installed.

I. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
a. Indoor Clean, Dry Locations: Type 1.
b. Outdoor Locations: Type 3R.
2. Boxes: Galvanized steel unless otherwise indicated.
a. Provide wiring gutters sized to accommodate the conductors to be installed.
b. Provide painted steel boxes for surface-mounted panelboards where indicated, finish to match fronts.
3. Fronts:
a. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
4. Lockable Doors: All locks keyed alike unless otherwise indicated.

J. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

K. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.

L. Load centers are not acceptable.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Fusible Switches:
1. Description: Quick-make, quick-break, dead-front fusible switch units complying with NEMA KS 1, and listed and labeled as complying with UL 98; ratings, configurations, and features as indicated on the drawings.
2. Fuse Clips: As required to accept indicated fuses.

3. Provide externally operable handle with means for locking in the OFF position. Provide means for locking switch cover in the closed position. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

2.4 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Factory test panelboards according to NEMA PB 1.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive panelboards.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship).

B. Install products in accordance with manufacturer's instructions.

C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

E. Provide required support and attachment in accordance with Section 26 0529.

F. Provide required seismic controls in accordance with Section 26 0548.

G. Install panelboards plumb.

H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.

I. Mount floor-mounted power distribution panelboards on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.

J. Provide grounding and bonding in accordance with Section 26 0526.

K. Install all field-installed branch devices, components, and accessories.

L. Provide fuses complying with Section 26 2813 for fusible switches as indicated.

M. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

N. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.

O. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

P. Install panelboards in accordance with NEMA PB 1.1 and NECA 1.

Q. Install panelboards plumb. Install recessed panelboards flush with wall finishes.

R. Height: 6 feet to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above floor.

S. Provide filler plates to cover unused spaces in panelboards.

T. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
   1. Fire detection and alarm circuits.
   2. Communications equipment circuits.
   3. Intrusion detection and access control system circuits.
   4. Video surveillance system circuits.

U. Identify panelboards in accordance with Section 26 0553.

V. Provide identification nameplate for each panelboard in accordance with Section 26 0553.

W. Provide arc flash warning labels in accordance with NFPA 70.

X. Provide spare conduits out of each recessed panelboard to an accessible location above ceiling. Identify each as SPARE.

Y. Ground and bond panelboard enclosure according to Section 26 0526.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Perform field inspection and testing in accordance with Section 01 4000.

C. Inspect and test in accordance with NETA ATS, except Section 4.

D. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.

E. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.

F. Correct deficiencies and replace damaged or defective panelboards or associated components.

G. Perform inspections and tests listed in NETA STD ATS, Section 7.5 for switches, Section 7.6 for circuit breakers.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of panelboard fronts.

C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.5 CLEANING

A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 26 2550 - GENERATOR DOCKING STATION

PART 1 GENERAL

1.1 QUALITY ASSURANCE

1.2 ELECTRICAL COMPONENTS, DEVICES, AND ACCESSORIES: LISTED AND LABELED AS DEFINED IN NFPA 70, BY A QUALIFIED TESTING AGENCY, AND MARKED FOR INTENDED LOCATION AND APPLICATION.

1.3 COMPLY WITH NFPA 70.

1.4 GUARANTEE/WARRANTY

1.5 THE EQUIPMENT INSTALLED UNDER THIS CONTRACT SHALL BE LEFT IN PROPER WORKING ORDER. REPLACE, WITHOUT ADDITIONAL CHARGE, NEW WORK OR MATERIAL WHICH DEVELOPS DEFECTS FROM ORDINARY USE WITHIN ONE YEAR.

1.6 NEW MATERIALS AND EQUIPMENT SHALL BE GUARANTEED AGAINST DEFECTS IN COMPOSITION, DESIGN OR WORKMANSHIP. GUARANTEE CERTIFICATES SHALL BE FURNISHED.

PART 2 PRODUCTS

2.1 GENERATOR DOCKING STATION

2.2 MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY THE FOLLOWING:

A. TRYSTAR: GDS --- TRYSTAR, info@trystar.com

B. Or approved equal.

2.3 GENERAL REQUIREMENTS

2.4 UNIT SHALL BE A GENERATOR DOCKING STATION CAPABLE OF COMPLYING WITH THE LATEST NEC 700.3 REQUIREMENTS. NEC 700.3. DOCKING STATION SHALL INCLUDE ONE SET OF TEMPORARY GENERATOR CAMLOKS.

2.5 ENTIRE PACKAGE MUST BE LISTED TO ETL OR UL 1008 STANDARDS. UL LISTING OF INDIVIDUAL COMPONENTS IS NOT ACCEPTABLE.

2.6 ENCLOSURES:

A. Pad mount, NEMA 3R rain-tight, aluminum enclosure.
   1. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or portable load bank. NEMA 3R integrity shall be maintained with access plate open for cable entry.
   2. Front, side, and bottom through a front access panel shall be accessible for maintenance.

3. Top, side, and bottom through a front access panel shall be accessible for permanent cabling.

B. Finishes:
1. Paint after fabrication. Powder coated Hammer Gray.

2.7 PHASE, NEUTRAL, AND GROUND BUSES:

A. Material: Silver-plated, Tin-plated or Hard-drawn copper, specified upon order.

B. Equipment Ground Bus: bonded to box.

C. Isolated Ground Bus: insulated from box.

D. Ground Bus: 25%, 50% or 100% of phase size.

E. Neutral Bus: Neutral bus rated 100 percent of phase bus.

F. Round edges on bus.

G. Entire construction shall be Bussing. Cabling between Camloks or sections shall not be acceptable.

2.8 PORTABLE GENERATOR CONNECTORS SHALL BE CAMLOK STYLE MOUNTED ON GLAND PLATE.

A. An additional Set of Mechanical Lugs, accessible from the front of the docking station, shall also be required for temporary generator connection on pad mount units.

B. Camloks are required to have phase color identification paint at their mounting point to the docking station. Camlok phase paint shall be as follows
1. A phase - Brown
2. B phase - Yellow
3. C phase - Purple or Orange
4. N Neutral - White
5. G Ground - Green

2.9 PERMANENT CONNECTORS SHALL BE BROAD RANGE SET-SCREW TYPE, LOCATED BEHIND AN ALUMINUM BARRIER.

2.10 VOLTAGE & PHASE SHALL BE AS SHOWN ON PROJECT ONE LINE DRAWING. CAMLOKS SHALL BE COLOR CODED AS APPROPRIATE FOR THE SPECIFIED VOLTAGE.

2.11 AMPERAGE RATING SHALL BE AS SHOWN ON PROJECT ONE LINE DRAWING.

2.12 A REMOTE START TERMINAL WILL BE PROVIDED, SO THAT A TEMPORARY GENERATOR CAN BE REMOTELY START AND STOPPED IN AN IDENTICAL MANNER AS THE PERMANENT GENERATOR SET.

PART 3 EXECUTION

3.1 EXAMINATION

3.2 EXAMINE ELEMENTS AND SURFACES TO RECEIVE GENERATOR DOCKING STATION FOR COMPLIANCE WITH INSTALLATION TOLERANCES AND OTHER CONDITIONS AFFECTING PERFORMANCE OF THE WORK.

3.3 PROCEED WITH INSTALLATION ONLY AFTER UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED.

3.4 INSTALLATION

3.5 SURFACE, FLUSH OR BASE MOUNTED: SPECIFIED WITH ORDER.

A. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.

3.6 TEMPORARY LIFTING PROVISIONS: REMOVE TEMPORARY LIFTING EYES, CHANNELS, AND BRACKETS AND TEMPORARY BLOCKING OF MOVING PARTS FROM ENCLOSURES AND COMPONENTS.

3.7 FIELD QUALITY CONTROL

3.8 THIRD PARTY TESTS AND INSPECTIONS TO INCLUDE THE FOLLOWING:

A. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

B. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Perform the following infrared scan tests and inspections and prepare reports:
   1. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each Generator Docking Station. Remove front panels so joints and connections are accessible to portable scanner.

3.9 GENERATOR DOCKING STATION WILL BE CONSIDERED DEFECTIVE IF THEY DO NOT PASS TESTS AND INSPECTIONS.

3.10 PREPARE TEST AND INSPECTION REPORTS, INCLUDING A CERTIFIED REPORT THAT IDENTIFIES GENERATOR DOCKING STATION AND THAT DESCRIBES SCANNING RESULTS. INCLUDE NOTATION OF DEFICIENCIES DETECTED, REMEDIAL ACTION TAKEN, AND OBSERVATIONS AFTER REMEDIAL ACTION.

END OF SECTION

SECTION 26 2726 - WIRING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Wall switches.

B. Receptacles.

C. Wall plates.

1.2 RELATED REQUIREMENTS

A. Section 26 0533.16 - Boxes for Electrical Systems.

B. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.3 REFERENCE STANDARDS

A. FS W-C-596 - Connector, Electrical, Power, General Specification for; 2017h.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

C. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2010.

D. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2015).

E. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2016.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. UL 498 - Attachment Plugs and Receptacles; Current Edition, Including All Revisions.

H. UL 514D - Cover Plates for Flush-Mounted Wiring Devices; Current Edition, Including All Revisions.

I. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

J. UL 1310 - Class 2 Power Units; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
   2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
   3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.

4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
5. Notify DEDC, LLC of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

B. Sequencing:
1. Do not install wiring devices until final surface finishes and painting are complete.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

B. Products: Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Arrow-Hart, a brand of Cooper Wiring Devices: www.cooperindustries.com

B. Leviton Manufacturing, Inc: www.leviton.com.

C. P & S_____.

D. Bryant

E. Hubbell

2.2 WIRING DEVICE APPLICATIONS

A. Provide wiring devices suitable for intended use and with ratings adequate for load served.

B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.

C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.

D. Provide tamper resistant receptacles for receptacles installed in dwelling units.

E. Provide tamper resistant receptacles for all receptacles installed in waiting/reception areas.

F. Provide GFCI protection for receptacles installed within 6 feet of sinks.

G. Provide GFCI protection for receptacles installed in kitchens.

H. Provide GFCI protection for receptacles serving electric drinking fountains.

I. Unless noted otherwise, do not use combination switch/receptacle devices.

J. For flush floor service fittings, use tile rings for installations in tile floors.

K. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

2.3 WIRING DEVICE FINISHES

A. Provide wiring device finishes as described below unless otherwise indicated.

B. Wiring Devices Connected to Emergency Power: Red with red nylon wall plate.

2.4 ALL WIRING DEVICES

A. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

B. Finishes: As coordinated with architect.

2.5 WALL SWITCHES

A. Wall Switches: Extra Heavy Duty Industrial Series, AC only general-use snap switch, complying with NEMA WD 6 and WD 1.
   1. Body and Handle: Ivory plastic with toggle handle.
   2. Ratings:
      a. Voltage: 120 volts, AC.
      b. Current: 20 amperes.

B. Switch Types: Single pole, 3-way, and 4-way.

2.6 RECEPTACLES

A. Manufacturers:
   1. Hubbell Incorporated; _____: www.hubbell.com/#sle.
   2. Leviton Manufacturing Company, Inc; _____: www.leviton.com/#sle.

3. Lutron Electronics Company, Inc; Designer Style: www.lutron.com/#sle.
4. Pass & Seymour, a brand of Legrand North America, Inc; _____: www.legrand.us/#sle.
5. Substitutions: See Section 01 6000 - Product Requirements.

B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
   1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
   2. NEMA configurations specified are according to NEMA WD 6.

C. Convenience Receptacles:
   1. Standard Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.

D. GFCI Receptacles:
   1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
      a. Provide test and reset buttons of same color as device.
   2. Standard GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
   3. Weather Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.

E. USB Charging Devices:
   1. USB Charging Devices - General Requirements: Listed as complying with UL 1310.
      a. Charging Capacity - Two-Port Devices: 2.1 A, minimum.
   2. USB Charging/Tamper Resistant Receptacle Combination Devices: Two-port (Type A) USB charging device and receptacle, commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; rectangular decorator style.

F. Receptacles: Extra Heavy Duty Industrial Series, complying with NEMA WD 6 and WD 1.
   1. Device Body: Ivory plastic.
   2. Configuration: NEMA WD 6, type as specified and indicated.

G. Convenience Receptacles: Type 5-20R.

H. Single Convenience Receptacles.

I. Duplex Convenience Receptacles.

J. GFCI Receptacles: 5-20R Duplex Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

2.7 WALL PLATES

A. Wall Plates: Comply with UL 514D.
   1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
   2. Size: Standard.
   3. Screws: Metal with slotted heads finished to match wall plate finish.

B. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.

C. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.

D. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

E. Decorative Cover Plates: , Smooth stainless steel.

F. Surface Mounted Device Wall Plates: Stamped steel.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

C. Verify that wall openings are neatly cut and will be completely covered by wall plates.

D. Verify that final surface finishes are complete, including painting.

E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

F. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.

B. Perform work in a neat and workmanlike manner in accordance with NECA 1, including mounting heights specified in that standard unless otherwise indicated.

C. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of wiring devices provided under this section.
   1. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
   2. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
   3. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify DEDC, LLC to obtain direction prior to proceeding with work.
   4. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.

D. Install wiring devices in accordance with manufacturer's instructions.

E. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

F. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.

G. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.

H. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

I. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices.

J. Install securely, in a neat and workmanlike manner, as specified in NECA 1.

K. Install wiring devices plumb and level with mounting yoke held rigidly in place.

L. Install wall switches with OFF position down.

M. Do not share neutral conductor on branch circuits utilizing wall dimmers.

N. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.

O. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

P. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

Q. Identify wiring devices in accordance with Section 26 0553.

R. Connect wiring device grounding terminal to outlet box with bonding jumper.

S. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

T. Connect wiring devices by wrapping conductor around screw terminal.

U. Install galvanized steel cover plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted switches & outlets.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes provided under Section 26 0537 to obtain mounting heights specified.

B. Install wall switch 48 inches above finished floor.

C. Install convenience receptacle 18 inches above finished floor.

D. Install convenience receptacle 6 inches above counter.

E. Install telephone jack 18 inches above finished floor.

F. Install telephone jack for side-reach wall telephone to position top of telephone at 54 inches above finished floor.

G. Install telephone jack for forward-reach wall telephone to position top of telephone at 48 inches above finished floor.

3.5 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect each wiring device for damage and defects.

C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.

D. Operate each wall switch with circuit energized and verify proper operation.

E. Test each receptacle to verify operation and proper polarity.

F. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.

G. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.6 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.7 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

SECTION 26 2816.16 - ENCLOSED SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Enclosed safety switches.

B. Nonfusible switches.

1.2 RELATED REQUIREMENTS

A. Section 26 0526 - Grounding and Bonding for Electrical Systems.

B. Section 26 0529 - Hangers and Supports for Electrical Systems.

C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

D. Section 26 2813 - Fuses.

E. Section 26 2913 - Enclosed Controllers: Manual motor controllers.

1.3 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

B. NEMA FU 1 - Low Voltage Cartridge Fuses; National Electrical Manufacturers Association; 2002 (R2007).

C. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   4. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

A. Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Eaton Corporation; _____: www.eaton.com/#sle.

B. Schneider Electric; Square D Products; _____: www.schneider-electric.us/#sle.

C. Siemens: www.sea.siemens.com.

D. Substitutions: See Section 01 6000 - Product Requirements.

E. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 COMPONENTS

A. Fusible Switch Assemblies: NEMA KS 1, Type HD enclosed load interrupter knife switch.
   1. Externally operable handle interlocked to prevent opening front cover with switch in ON position.
   2. Handle lockable in OFF position.

3. Fuse clips: Designed to accommodate NEMA FU1, Class R fuses. Provide rejection clips to reject all other than Class R fuses.
4. Fuse extenders where indicated on contract drawings.

B. Nonfusible Switch Assemblies: NEMA KS 1, Type HD enclosed load interrupter knife switch.
1. Externally operable handle interlocked to prevent opening front cover with switch in ON position.
2. Handle lockable in OFF position.
3. Electrical interlocks, break before switch opens and close after switch closes, where indicated on contract drawings.

C. Enclosures: NEMA KS 1.
1. Interior Dry Locations: Type 1.
2. Exterior Locations: Type 3R.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed safety switches.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install enclosed switches plumb.

F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

G. Provide grounding and bonding in accordance with Section 26 0526.

H. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

I. Identify enclosed switches in accordance with Section 26 0553.

J. Provide identification nameplate for each enclosed switch in accordance with Section 26 0553.

K. Provide arc flash warning labels in accordance with NFPA 70.

L. Install fuses in fusible disconnect switches.

M. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.

D. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 26 2913 - ENCLOSED CONTROLLERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Enclosed NEMA controllers for low-voltage (600 V and less) applications:
   1. Manual motor starters.

B. Overcurrent protective devices for motor controllers, including overload relays.

1.2 RELATED REQUIREMENTS

A. Section 26 0526 - Grounding and Bonding for Electrical Systems.

B. Section 26 0529 - Hangers and Supports for Electrical Systems.

1.3 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2018.

C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2000, with Errata (2008).

D. NEMA ICS 6 - Industrial Control and Systems: Enclosures; 1993 (Reaffirmed 2016).

E. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. UL 60947-1 - Low-Voltage Switchgear and Controlgear - Part 1: General Rules; Current Edition, Including All Revisions.

H. UL 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters - Electromechanical Contactors and Motor-starters; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
   2. Coordinate the work to provide motor controllers and associated overload relays suitable for use with the actual motors to be installed.
   3. Coordinate the work to provide controllers and associated wiring suitable for interface with control devices to be installed.

4. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
5. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
6. Notify DEDC, LLC of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
   1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.

C. Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

A. Maintain field conditions within required service conditions during and after installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. ABB/GE; _____: www.geindustrial.com/#sle.

B. Eaton Corporation; _____: www.eaton.com/#sle.

C. Schneider Electric; Square D Products; _____: www.schneider-electric.us/#sle.

D. Substitutions: See Section 01 6000 - Product Requirements.

E. Source Limitations: Furnish enclosed motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.

2.2 ENCLOSED CONTROLLERS

A. Provide enclosed controller assemblies consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Description: Enclosed controllers complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; ratings, configurations and features as indicated on the drawings.

D. Service Conditions:
   1. Provide controllers and associated components suitable for operation under the following service conditions without derating:
      a. Altitude:
         1) Class 1 Km Equipment (devices utilizing power semiconductors, e.g. variable frequency controllers): Less than 3,300 feet.
         2) Class 2 Km Equipment (electromagnetic and manual devices): Less than 6,600 feet.
      b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
   2. Provide controllers and associated components suitable for operation at indicated ratings under the service conditions at the installed location.

E. Short Circuit Current Rating:
   1. Provide controllers with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

F. Conductor Terminations: Suitable for use with the conductors to be installed.

G. Enclosures:
   1. Comply with NEMA ICS 6.
   2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1 or Type 12.
      b. Outdoor Locations: Type 3R or Type 4.
   3. Finish: Manufacturer's standard unless otherwise indicated.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Overload Relays:
   1. Provide overload relays and, where applicable, associated current elements/heaters, selected according to actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.

2. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
3. Trip-free operation.
4. Visible trip indication.
5. Resettable.
    a. Employ manual reset unless otherwise indicated.
    b. Do not employ automatic reset with two-wire control.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that ratings of enclosed controllers are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed controllers.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install controllers in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install enclosed controllers plumb and level.

F. Provide grounding and bonding in accordance with Section 26 0526.

G. Install all field-installed devices, components, and accessories.

H. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

I. Set field-adjustable controllers and associated components according to installed motor requirements, in accordance with manufacturer's recommendations and NFPA 70.

J. Set field-adjustable circuit breaker tripping function settings as indicated.

3.3 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Motor Starters: Perform inspections and tests listed in NETA ATS, Section 7.16.1.1. Tests listed as optional are not required.

D. Correct deficiencies and replace damaged or defective enclosed controllers or associated components.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

A. Clean dirt and debris from controller enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

A. See Section 01 7800 - Closeout Submittals, for closeout submittals.

B. See Section 01 7900 - Demonstration and Training, for additional requirements.

3.7 PROTECTION

A. Protect installed enclosed controllers from subsequent construction operations.

END OF SECTION

SECTION 26 3213 - ENGINE GENERATOR

PART 1 GENERAL

1.1 SUMMARY

A. This section includes the following items from a single supplier:
   1. Engine Generator Set.
   2. Enclosure
   3. Custom sub-base fuel tank
   4. Related Accessories as specified
      a. Related Requirements
         1) It is the intent of this specification to secure an engine-driven generator set that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
         2) Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been are omitted or have been taken exception to, and a complete description of all deviations.
         3) It is the intent of this specification to secure a generator set system that has been tested during design verification, in production, and at the final job site. The generator set will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
         4) All equipment shall be new and of current production by an international, power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

1.2 SUBMITTALS

A. Action Submittals
   1. Product Data
   2. The submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
   3. Shop Drawings
      a. Informational Submittal
         1) Certificates
         2) The generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.

3) Test and Evaluation Reports
4) Manufacturer's Instruction
5) Source Quality Control Submittals
6) Field or Site Quality Control
7) Manufacturer's Report

b. Closeout Submittal
1) Maintenance Contracts
2) Operation And Maintenance Data
3) Warranty Documentation
4) Record Documentation

c. Maintenance Material Submittals

1.3 QUALITY ASSURANCE

A. Regulatory Agency
1. The generator set shall conform to the requirements of the following codes and standards:
a. CSA C22.2, No. 14-M91 Industrial Control Equipment.
b. EN50082-2, Electromagnetic Compatibility-Generic Immunity Requirements, Part 2: Industrial.
c. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
d. IEC8528 part 4, Control Systems for Generator Sets.
e. IEC Std 61000-2 and 61000-3 for susceptibility, 61000-6 radiated and conducted electromagnetic emissions.
f. IEEE446 Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
g. NFPA 70, National Electrical Code, Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
h. NFPA 99, Essential Electrical Systems for Health Care Facilities.
i. NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not substitute for this requirement.
1) Qualifications
(a) The equipment shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
(1) The power system shall be produced by a manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year.
(2) Manufacturers
(3) The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.
(4) Suppliers
(5) Testing Agencies

(6) Licensed Professional
(7) Preconstruction testing

1.4 FIELD OR SITE CONDITIONS

A. Ambient Conditions
1. Engine- generator set shall operate in the following conditions without any damage to the unit or its loads.
a. Ambient Temperature: 77 °F
b. Altitude : 500 ft
c. Relative Humidity: 95%
d. Existing Conditions

1.5 WARRANTY

A. Manufacturer's Warranty
1. The generator set shall include a standard warranty covering one (5) year or 10,000 hours, whichever occurs first, to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
2. The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Manufacturer:
1. The generator set shall be a Kohler model 300REZXC with a 4UA13 alternator or approved equal by:
2. Caterpillar
3. MTU

B. Equipment
1. The generator set shall provide 375 kVA and 300.00 kW when operating at 120/208 volts, 60 Hz, 0.80 power factor. The generator set shall be capable of a 130°C Standby rating while operating in an ambient condition of less than or equal to 77 °F and a maximum elevation of 500 ft. above sea level. The standby rating shall be available for the duration of the outage.
a. Engine
1) The minimum 14.6 liter displacement engine shall deliver a minimum of 459 BHP at a governed engine speed of 1800 rpm, and shall be equipped with the following:
(a) Electronic isochronous governor capable of 0.25% steady-state frequency regulation

(b) 24-volt positive-engagement solenoid shift-starting motor
(c) 60-ampere automatic battery charging alternator with a solid-state voltage regulation
(d) Positive displacement, full-pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain
(e) Dry-type replaceable air cleaner elements for normal applications
(f) The turbocharged engine shall be fueled by natural gas.
(g) The engine shall have a minimum of 8 cylinders and be liquid-cooled
(1) The engine shall be EPA certified from the factory
(2) The generator must accept rated load in one-step.

2) Cooling System
(a) The engine shall be liquid-cooled by a closed loop, unit mounted radiator rated to operate the generator set at full load at an ambient temperature of 50 degrees C (122 degrees F). The radiator fan and other rotating engine parts shall be guarded against accidental contact.

2. Standard Air Cleaner
a. The air cleaner shall provide engine air filtration which meets the engine manufacturer's specifications under typical operating conditions.
b. Battery
1) Each generator set requires two BCI group 31 batteries which must meet the engine manufactures' specifications for the ambient conditions specified in Part 1 Project Conditions and shall comply with the NFPA requirements for engine cranking cycles. Each battery shall be rated according to SAE Standards J-537 with a minimum cold cranking amp of 1000 amps and a minimum reserve capacity of 185 Minutes at 80F. The battery plates shall be constructed of a Calcium-Lead alloy to provide long waterless operation and extended battery life. The battery elements must be anchor-locked with full-frame grids and tight-packed commercial plates to resist the effects of vibration. The battery must contain a handle to aid in lifting and the case must be constructed of polypropylene to resist breakage and extend service life. Removable cell covers shall be provided to allow for checking of electrolyte specific gravity.
2) Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.

3. Housing
a. Level 2 Sound Attenuated Enclosure

C. The generator set shall be supplied with a Level 2 Sound Attenuated Enclosure, providing a sound level of 75 dB(A) while the generator is operating at 100% load at 7 meters (23 feet) using acoustic insulation and acoustic-lined inlet hoods, and constructed from high strength, low alloy 14 gauge galvanized steel. The acoustic insulation used shall meet UL 94 HF1 flammability classification. The enclosure shall be manufactured from bolted panels to facilitate service, future modifications, or field replacement. The enclosure shall use external vertical air inlet and outlet hoods with 90 degree angles to discharge air up and reduce noise. The enclosure shall have an integral rodent guard and skid end caps and shall have bracing to meet 241 kph (150 mph) wind loading.

D. The enclosure components and skid shall be cleaned with a two-stage alkaline cleaning process to remove grease, grit, and grime from parts. Components shall then be subjected to a Zirconium-based

conversion coating process to prepare the metal for electro-coat (e-coat) adhesion. All enclosure parts shall receive a 100% epoxy primer electro-coat (e-coat) with high-edge protection. Following the e-coat process, the parts shall be finish coated with powder baked paint for superior finish, durability, and appearance with a Power Armor TM industrial finish that provides heavy duty durability in harsh conditions, and is fade-, scratch- and corrosion-resistant.

E. The enclosure must surpass a 3,000 hour salt spray corrosion test per ASTM B-1117.

F. Enclosures will be finished in the manufacturer's standard color.

G. The enclosures shall allow the generator set to operate at full load in an ambient temperature of 50°C with no additional derating of the electrical output of the generator set.

H. Enclosures shall be equipped with sufficient side and end doors to allow access for operation, inspection, and service of the unit and all options. Minimum requirements are two doors per side. When the generator set controller faces the rear of the generator set, an additional rear facing door is required. Access to the controller and main line circuit breaker shall meet the requirements of the National Electric Code.

I. Doors shall be fitted with hinges, hardware, and the doors shall be removable.

J. Doors shall be equipped with lockable latches. Locks shall be keyed alike. Door locks shall be recessed to minimize potential of damage to door/enclosure.

K. A duct between the radiator and air outlet shall be provided to prevent re-circulation of hot air.

L. The complete exhaust system shall be internal to the enclosure.

M. The critical silencer shall be fitted with a tailpipe and rain cap.

1. Controller
    a. Advanced Power Management 402 (APM402) Generator Set Controller
        1) The generator set controller shall be a microprocessor-based control system that will provide automatic starting, system monitoring, and protection. The controller system shall also provide local monitoring and remote monitoring. The control system shall be capable of PC based updating of all necessary parameters, firmware, and software.
        2) The controller shall be mounted on the generator set and shall have integral vibration isolation. The controller shall be prototype and reliability tested to ensure operation in the conditions encountered.
            (a) Codes and Standards
                (1) The generator set controller shall meet NFPA 110 Level 1 requirements and shall include an integral alarm horn as required by NFPA.
                (2) The controller shall meet NFPA 99 and NEC requirements.
                (3) The controller shall be UL 508 listed.
            (b) Applicability
                (1) The controller shall be a standard offering in the manufacturer's controller product line.
                (2) The controller shall support 12-volt and 24volt starting systems.

(3) The controller's environmental specification shall be: -40°C to 70°C operating temperature range and 5-95% humidity, non-condensing.
(4) The controller shall mount on the generator or remotely within 40 feet with viewable access.

(c) Controller Buttons, Display and Components
(1) The generator set controller shall include the following features and functions:
(2) Push button Master Control buttons. The buttons shall be tactile-feel membrane with an indicator light to initiate the following functions:
(3) Run Mode: When in the run mode the generator set shall start as directed by the operator.
(4) Off/Reset Mode: When in the Off/Reset mode the generator set shall stop, the reset shall reset all faults, allowing for the restarting of the generator set after a shutdown.
(5) Auto Mode: When in Auto the mode the generator set shall be ready to accept a signal from a remote device.
(6) Emergency Stop Switch. The remote stop switch shall be red in color with a "mushroom" type head. Depressing the stop button will immediately stop the generator set and lockout the generator set for any automatic remote starting.
(7) Push Button/Rotary Selector dial. This dial shall be used for selection of all Menus and sub-menus. Rotating the dial moves you through the menus, pushing the dial selects the menu and function/features in that menu. Pushing the button selects the feature/function and sub-menus.
(8) Digital Display. The digital display shall be alphanumeric, with 2 lines of data and approximately 24 charters. The display shall have back lighting for ease of operator use in high and low light conditions. The display shall display status of all faults and warnings. The display shall also display any engine faults. While the generator set is running, the display shall scroll all-important information across the screen for ease of operator use. The scroll can be stopped by pushing the rotary dial. The display shall fall asleep when the generator set is not running and will wake-up when the generator set starts, or the rotary dial is depressed.
(9) Fault Light. The controller shall have an annunciator fault light that glows red for faults and yellow for warnings. These faults and warnings shall be displayed in the digital display. The fault light will also glow yellow when not in AUTO.
(10) Alarm Horn. The controller shall provide an alarm horn that sounds when any faults or warnings are present. The horn shall also sound when the controller is not in the AUTO mode.
(11) Alarm Silence/Lamp Test Button. When this button is depressed, it shall test all controller lamps. This button will also silence the alarm horn when the unit is not AUTO.
(12) USB Connection. The controller shall have a USB connection on the face of the controller. This connection shall allow for updating of all software and firmware. This port shall also allow for all servicing of generator set parameters, fault diagnostics and viewing of all controller information via use a laptop computer.

(13) Dedicated user inputs. The controller shall have dedicated inputs for remote emergency stop switch, remote 2-wire star for transfer switch and auxiliary shutdown.
(14) The controller shall have auto resettable circuit protection integral on the circuit board.

(d) System Controller Monitoring and Status Features and Functions
(1) The generator controller shall display and monitor the following engine and alternator functions and allow adjustments of certain parameters at the controller:
(2) Overview menu
(3) Active shutdowns and warnings shall be displayed if present and without the need of operator interface
(4) Engine runtime with total hours
(5) Average line to line voltage
(6) Coolant temperature
(7) Fuel level or pressure
(8) Oil pressure
(9) Battery voltage
(10) Software version
(11) Frequency
(12) Average current
(13) Engine metering menu.
(14) Engine speed
(15) Oil pressure
(16) Coolant temperature
(17) Battery voltage
(18) Generator metering menu.
(19) Total power in VA
(20) Total power in W
(21) Rated power % used
(22) Voltage L-L and L-N for all phases
(23) Current L1, L2, L3
(24) Frequency
(25) Generator set information.
(26) Generator set model number
(27) Generator set serial number
(28) Controller set number
(29) Generator set run time.
(30) Engine run time total hours
(31) Engine loaded total hours
(32) Number of engine starts
(33) Total energy in kW
(34) Generator set system
(35) System voltage
(36) System frequency 50/60Hz

(37) System phase, single/three phase
(38) Power rating kW
(39) Amperage rating
(40) Power type standby/prime
(41) Measurement units, metric/English units adjustable
(42) Alarm silence, always or auto only
(43) Generator set calibration, the following are adjustable at the controller.
(44) Voltage L-L and L-N all phases
(45) Current L1, L2, L3
(46) Reset all calibrations
(47) Voltage regulation, +/-0.5% regulation, the following is adjustable at the controller.
(48) Voltage Adjustable +/- 10%
(49) Digital and Analog Inputs and outputs
(50) Displays settings and status
(51) Event Log
(52) Stores event history, up to 1000 events

(e) Controller Engine control features and functions
(1) Automatic restart - the controller has automatic restart feature that initiates the start routine and re-crank after a failed start attempt.
(2) Cyclic cranking - the controller shall have programmable cyclic cranking
(3) Engine starting aid - the controller shall have the capability of providing control for an optional engine starting aid.
(4) The control system shall include time delays for engine start and cool down.
(5) The control system shall interface with the engine ECM and display engine fault codes and warnings. The ECM shall also include sender failure monitoring to help distinguish between failed senders and actual failure conditions.
(6) The controller shall monitor and display engine governor functions with include steady state and transient frequency monitoring

(f) Controller Alternator control features and functions
(1) Integrated hybrid voltage regulator. The system shall have integral microprocessor-based voltage regulator system that provides +/- 5% voltage regulation, no-load to full load with three phase sensing. The system is prototype tested and control variation of voltage to frequency. The voltage regulator shall be adjustable at the controller with maximum +/- 10% adjustable of nominal voltage.
(2) AC output voltage regulator adjustment. The system shall allow for adjustment of the integral voltage regulator with maximum of +/- 10% adjustment of the system voltage.
(3) Alternator thermal overload protection. The system shall have integral alternator overload and short circuit protection matched to each alternator for the particular voltage and phase configuration.
(4) Power metering. The controller digitally displays power metering of kW and kVA.

(g) Other control features and functions
  (1) Event logging. The controller keeps a record of up to 1000 events, for warning and shutdown faults. This fault information becomes a stored record of systems events and can be reset.
  (2) Historical data logging. The controller total number of generator set successful start shall be recorded and displayed.
  (3) Programmable access. The control system shall include a USB port that gives service technicians the ability to provide software and firmware upgrades. The system shall also be capable of allowing setting of all critical parameters using the service software and a laptop computer. All parameters and setting should be capable to being stored on a laptop for future upgrades of printing for analysis.

(h) Generator Set Warning, Shutdown Alarm and Status
  (1) The generator set shall have alarms and status indication lamps that show non-automatic status and warning and shutdown conditions. The controller shall indicate with a warning lamp and or alarm and on the digital display screen any shutdown, warning or engine fault condition that exists in the generator set system. The following alarms and shutdowns shall exist as a minimum:
  (2) Engine functions
  (3) Critical high fuel level (alarm)
  (4) ECM communication loss (shutdown)
  (5) ECM diagnostics (alarm & shutdown)
  (6) Engine overspeed (shutdown)
  (7) Engine start aid active
  (8) Engine under speed (shutdown)
  (9) Fuel tank leak (alarm & shutdown)
  (10) High DC battery voltage (alarm)
  (11) High coolant temperature (alarm & shutdown)
  (12) High fuel level (alarm)
  (13) Low DC battery voltage (alarm)
  (14) Low coolant level (shutdown)
  (15) Low coolant temperature (alarm)
  (16) Low cranking voltage (alarm)
  (17) Low engine oil level (alarm & shutdown)
  (18) Low fuel pressure (alarm)
  (19) Low oil pressure (alarm & shutdown)
  (20) No coolant temperature signal (shutdown)
  (21) No oil pressure signal (shutdown)
  (22) Overcrank (shutdown)
  (23) Speed sensor fault (alarm)
  (24) Generator functions
  (25) AC sensing loss over & under current (alarm & shutdown)
  (26) Alternator protection (shutdown)
  (27) Ground fault input (alarm)

(28) kW overload (shutdown)
(29) Locked rotor (shutdown)
(30) Over-frequency (shutdown)
(31) Over AC voltage (shutdown)
(32) Under-frequency (shutdown)
(33) Under AC voltage (shutdown)
(34) Emergency stop (shutdown)
(35) Other General functions
(36) Battery charger fault (alarm)
(37) Common fault (shutdown)
(38) Common warning (alarm)
(39) Master switch not in auto (alarm)
(40) Generator running
(41) Input/output fault (alarm)
(42) The generator set controller shall also be capable of meeting all necessary NFPA 110 level 1 requirements that include several of the above along with; EPS supplying load, Master switch "not in auto", and contacts for local and remote common alarm.

(i) Communications
(1) If the generator set engine is equipped with an ECM (engine control module), the controller shall communicate with the ECM for control, monitoring, diagnosis, and meet SAE J1939 standards
(2) Kohler proprietary RBUS communication shall be available.
(3) A RBUS shall be able to monitor and alter parameters and start or stop a generator.
(4) The controller shall have the capability to communicate to a personal computer (IBM or compatible) and appropriate application software
(5) A variety of connections shall be available based on requirements:
(6) A single control connection to a PC via USB
(7) Internet connection via Ethernet
(8) Generator and transfer switch controls shall be equipped with communications modules capable of connecting to the same communication network.

2. Generator Overcurrent and Fault Protection
a. The generator shall be provided with a factory installed, 100% rated line circuit breaker rated at 800.00 amperes that is UL489 listed. Line circuit breakers shall be sized for the rated ampacity of the loads served by the breaker per the NEC.
b. The circuit breaker(s) shall incorporate an electronic trip device with the following characteristics:
1) Adjustable long time delay
2) Adjustable short time delay [As applicable]
3) Instantaneous
(a) Load side lugs shall be provided from the factory. The line circuit breaker shall include auxiliary contacts, shunt trip, under voltage trip, alarm switch, and

overcurrent switch functionality. Load side breaker connections made at the factory shall be separated from field connections.

(b) The shunt trip device shall be connected to trip the generator breaker when the generator-set is shut down by other protective devices.

(c) Barriers to provide segregation of wiring from an emergency source to emergency loads from all other wiring and equipment, if required by the NEC, shall be provided.

3. Alternator
   a. The alternator shall be salient-pole, brushless, 2/3-pitch, with 4 bus bar provision for external connections, self-ventilated, with drip-proof construction and amortisseur rotor windings, and skewed for smooth voltage waveform. The ratings shall meet the NEMA standard (MG1-32.40) temperature rise limits. The insulation shall be class H per UL1446 and the varnish shall be a vacuum pressure impregnated, fungus resistant epoxy. Temperature rise of the rotor and stator shall be limited to 130°C Standby. The PMG based excitation system shall be of brushless construction controlled by a digital, three phase sensing, solid- state, voltage regulator. The AVR shall be capable of proper operation under severe nonlinear loads and provide individual adjustments for voltage range, stability and volts-per-hertz operations. The AVR shall be protected from the environment by conformal coating. The waveform harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rated load. The TIF factor shall not exceed 50.
      1) The alternator shall have a maintenance-free bearing, designed for 40000 hour B10 life. The alternator shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.
      2) The generator shall be inherently capable of sustaining at least 300% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current-support devices.
      3) Motor starting performance and voltage dip determinations shall be based on the complete generator set. The generator set shall be capable of supplying 736.00 LRKVA for starting motor loads with a maximum instantaneous voltage dip of 35%, as measured by a digital RMS transient recorder in accordance with IEEE Standard 115. Motor starting performance and voltage dip determination that does not account for all components affecting total voltage dip, i.e., engine, alternator, voltage regulator, and governor will not be acceptable. As such, the generator set shall be prototype tested to optimize and determine performance as a generator set system.
4. Vibration Isolation
   a. Vibration isolators shall be provided between the engine-alternator and heavy-duty steel base.

2.2 ACCESSORIES

A. The generator set shall be supplied with a 10-ampere automatic float/equalize battery charger capable of charging both lead-acid batteries, with the following features:
   1. Automatic 3-stage float to equalization charge
   2. Voltage regulation of 1% from no to full load over 10% AC input line voltage variations
   3. Battery charging current Ammeter and battery voltage voltmeter with 5% full-scale accuracy
   4. LED lamp for power ON indication
   5. Current limited during engine cranking, short circuit, and reverse polarity conditions

6. Temperature compensated for ambient temperatures for -40°C to 60°C
7. Alarm circuit board featuring alarm contacts for low battery voltage, high battery voltage, and battery charger malfunction.
8. UL 1012 Listed
9. CSA Certified
    a. Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.
        1) The generator set shall be supplied with a means to manually adjust the speed of the generator.
        2) The generator set shall be furnished with rodent guards to prevent rodent intrusion and protect internal components.
        3) The generator shall be equipped with a crankcase vent. The fumes coming from the vent (Blow-by) will need to be contained with the solids being separated and collected while the gases are being released back into the engine.
        4) Block Heater - The block heater shall be thermostatically controlled, 2500 watt, with isolating valves, to maintain manufacturers recommended engine coolant temperature to meet the start-up requirements of NFPA 99 and NFPA 110, Level 1.
        5) The exhaust piping shall be gas proof, seamless, stainless steel, flexible exhaust bellows and includes the flex exhaust tube and the mounting hardware.
        6) Supply flexible fuel lines to provide a flexible connection between the engine fuel fittings and the fuel supply tank piping and for the fuel return lines from the injector pump per engine manufacturer's recommendations. Flex line shall have a protective steel wire braid to protect the hose from abrasion.
        7) The generator set shall be supplied with a common failure relay to provide means of signaling fault and/or shutdown conditions.
            (a) The common failure relay shall remotely signal auxiliary faults, emergency stop, high engine temperature, low oil pressure, over crank, and over speed via one single-pole, double-throw relay with 10 amps at 120 VAC contacts.
            (b) The relay contacts shall be gold flashed to allow use of low current draw devices (100ma @ 28VDC min.).
            (c) Once energized the relay shall remain latched until the system is reset by the main controller switch.
        8) The generator set shall be provided with a run relay which shall provide a three-pole, double-throw relay with 10-amp/ 250 VAC contacts to indicate that the generator is running. The run relay dry contacts can be used for energizing or de-energizing customer devices while the generator is running (e.g. louvers, indicator lamps, etc.)
        9) Remote annunciator panel - The remote annunciator shall meet NFPA 110, Level 1 requirements and enable remote viewing of the generator status. The panel shall be connected to the generator controller via either network communication wires or via hard wired connections. Options shall be available to provide ATS source availability, contactor position, and loaded or unloaded test for up to four transfer switches. The panel shall have the capability to be either flush- mounted or surface-mounted. The annunciator shall meet UL508 requirements.

2.3 SOURCE QUALITY CONTROL

A. Non-Conforming Work
1. To ensure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and/or local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.
a. Design Prototype Tests. Components of the emergency system, such as the engine/generator set, transfer switch, and accessories, shall not be subjected to prototype tests because the tests are potentially damaging. Rather, similar design prototypes and preproduction models shall be subject to the following tests:
b. Maximum power (kW)
1) Maximum motor starting (kVA) at 35% instantaneous voltage dip.
2) Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-32.6.
3) Governor speed regulation under steady-state and transient conditions.
4) Voltage regulation and generator transient response.
5) Harmonic analysis, voltage waveform deviation, and telephone influence factor.
6) Three-phase short circuit tests.
7) Alternator cooling air flow.
8) Torsional analysis to verify that the generator set is free of harmful torsional stresses.
9) Endurance testing.
(a) Final Production Tests. Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
(1) Single-step load pickup
(2) Safety shutdown device testing
(3) Rated Power @ 0.8 PF
(4) Maximum power
(5) Upon request, a witness test, or a certified test record sent prior to shipment.
(6) Site Tests. The manufacturer's distribution representative shall perform an installation check, startup, and building load test. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
(7) Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
(8) Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery chargers, alternator strip heaters, remote annunciators, etc.
(9) Generator set startup under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during operation, normal and emergency line-to-line voltage and frequency, and phase rotation.

(10) Automatic start by means of a simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator set voltage, amperes, and frequency shall be monitored throughout the test.

END OF SECTION

SECTION 26 3223 - AUTOMATIC TRANSFER SWITCH

PART 1 GENERAL

1.1 SUMMARY

A. This section includes the following items from a single supplier:
   1. Automatic transfer switch
   2. Related Accessories as specified
   3. Related Requirements
      a. It is the intent of this specification to secure an automatic transfer switch that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
      b. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been are omitted or have been taken exception to, and a complete description of all deviations.
      c. It is the intent of this specification to secure an automatic transfer switch that has been tested during design verification, in production, and at the final job site. The automatic transfer switch will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
      d. All equipment shall be new and of current production by an international, power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

1.2 SUBMITTALS

A. Action Submittals
   1. Product Data
      a. The submittal shall include specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
         1) Shop Drawings
   2. Informational Submittal
      a. Certificates
      b. Test and Evaluation Reports
      c. Manufacturer's Instruction
      d. Source Quality Control Submittals
      e. Field or Site Quality Control

f. Manufacturer's Report

3. Closeout Submittals
   a. Maintenance Contracts
   b. Operation And Maintenance Data
   c. Warranty Documentation
   d. Record Documentation
   e. Software
4. Maintenance Material Submittals
   a. Literature

1.3 QUALITY ASSURANCE

A. Regulatory Agency
   1. The automatic transfer switch shall conform to the requirements of the following codes and standards:
      a. UL 1008 - Standard for Transfer Switch Equipment
      b. IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching EquipmentEN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
      c. NFPA 70 - National Electrical Code
      d. NFPA 99 - Essential Electrical Systems for Health Care Facilities
      e. NFPA 110 - Emergency and Standby Power Systems
      f. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
      g. NEMA Standard ICS 10-2005, Electromechanical AC Transfer Switch Equipment.
      h. EN61000-4-4 Fast Transient Immunity Severity Level 4
      i. EN61000-4-5 Surge Immunity Class 4 (voltage sensing and programmable inputs only)
      j. IEEE 472 (ANSI C37.90A) Ring Wave Test
      k. IEC Specifications for EMI/EMC Immunity (CISPR 11, IEC 1000-4-2, IEC 1000-4-3, IEC 1000-4-4, IEC 1000-4-5, IEC 1000-4-6, IEC 1000-4-8, IEC 1000-4-11)
      l. CSA C22.2 No. 178 certification
      m. Qualifications
         1) The automatic transfer switch shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
         2) A manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year shall produce the automatic transfer switch.
      n. Manufacturers
         1) The automatic transfer switch shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.
            (a) The manufacturer shall maintain a national service organization of employing personnel located throughout the contiguous United States. The Service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

(1) The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

o. Automatic transfer switch shall operate in the following conditions without any damage to the unit or its loads.
   1) Ambient Temperature: -4 to 158 Degrees F
   2) Relative Humidity: 5% to 95% noncondensing

1.4 WARRANTY

A. Manufacturer's Warranty
   1. The ATS shall include a standard warranty covering one (1) year to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
   2. The ATS manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

PART 2 PRODUCTS

2.1 CONTRACTOR-FURNISHED

A. New Products

2.2 EQUIPMENT

A. Equipment
   1. Furnish and install an automatic transfer switches system(s) with 3-Pole / 4-Wire, Solid Neutral, 800 Amps, 208V/60Hz. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.

B. Manufacturer
   1. Automatic transfer switches shall be Kohler - Standard transition KSS-ACTA-0800-S or equivalent switch by:
   2. ASCO
   3. Caterpillar
   4. MTU
   5. Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid date. Alternate bids shall include a line-by-line clarification of the specification marked with "D" for deviation; "E" for exception, and "C" for comply.

C. Construction

D. Enclosure

1. The ATS shall be furnished in a NEMA 1 enclosure.
2. All standard door mounted switches and indicating LEDs shall be integrated into a flush-mounted, interface membrane or equivalent in the enclosure door for easy viewing & replacement. The panel shall be capable of having a manual locking feature to allow the user to lockout all membrane mounted control switches to prevent unauthorized tampering. This cover shall be mounted with hinges and have a latch that may be padlocked. The membrane panel shall be suitable for mounting by others when furnished on open type units.

2.3 OPERATION

A. Controls
   1. A four line, 20 character LCD display and dynamic 4 button keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and control through the communications interface port or USB. The following parameters shall only be adjustable via a password protected programming on the controller:
      a. Nominal line voltage and frequency
      b. Single or three phase sensing
      c. Operating parameter protection
      d. Transfer operating mode configuration (Standard transition, Programmed transition, or Closed transition)

B. Voltage and Frequency
   1. Voltage (all phases) and frequency on both the normal and emergency sources shall be continuously monitored, with the following pickup, dropout, and trip setting capabilities (values shown as % of nominal unless otherwise specified):

	Parameter	Dropout/Trip	Pickup/Reset
b.	Under voltage	75 to 98%	85 to 100%
c.	Over voltage	106 to 135%	95 to 100% of trip
d.	Under frequency	95 to 99%	80 to 95%
e.	Over frequency	01 to 115%	105 to 120%
f.	Voltage unbalance	5 to 20%	3 to 18%

      g. Repetitive accuracy of all settings shall be within ± 0.5% over an operating temperature range of -20°C to 70°C.
      h. An adjustable dropout time for transient voltage and frequency excursions shall be provided. The time delays shall be 0.1 to 9.9 seconds for voltage and .1 to 15 seconds for frequency.
      i. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad, remotely via the communications interface port or USB.
      j. The controller shall be capable of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or BAC). Unacceptable phase rotation shall be indicated on the LCD; the service required LED and the annunciation through the communication protocol and dry contacts. In addition, the phase rotation sensing shall be capable of being disabled, if required.

k. The controller shall be capable of detecting a single phasing condition of a source, even though a voltage may be regenerated by the load. This condition is a loss of phase and shall be considered a failed source.
l. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases (phase to phase and phase to neutral), frequency, and phase rotation.

C. Time Delays

D. Additional Features

E. Operation Sequence

2.4 ACCESSORIES

2.5 STANDARD I/O MODULE. THE STANDARD I/O MODULE SHALL HAVE TWO PROGRAMMABLE INPUTS AND SIX PROGRAMMABLE OUTPUTS.

A. Inputs Available 2
1. Contact Closure
2. Current 5mA Max.
3. Connection Type Terminal Strip
4. Wire Size #14-24 AWG
5. Max Distance 700 feet
a. Outputs Available 6
1) Contact Type Form C (SPDT)
(a) Contact Rating 2A @ 30VDC, 500mA @ 125VAC
(1) Connection Type Terminal Strip
(2) Wire Size #14-24

2.6 SOURCE QUALITY CONTROL

2.7 TEST AND INSPECTION

A. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

B. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001.

END OF SECTION

SECTION 26 5100 - INTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires.

B. Emergency lighting units.

C. Exit signs.

D. Drivers.

E. Accessories.

1.2 RELATED REQUIREMENTS

A. Section 26 0529 - Hangers and Supports for Electrical Systems.

B. Section 26 0533.16 - Boxes for Electrical Systems.

C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

D. Section 26 0923 - Lighting Control Devices: Automatic controls for lighting including occupancy sensors, outdoor motion sensors, time switches, outdoor photo controls, and daylighting controls.

E. Section 26 2726 - Wiring Devices: Manual wall switches and wall dimmers.

1.3 REFERENCE STANDARDS

A. IES LM-79 - Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products; 2008.

B. IES LM-80 - Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules; 2015, with Errata (2017).

C. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems; 2006.

D. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems; 2006.

E. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility; 2012.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. UL 1598 - Luminaires; Current Edition, Including All Revisions.

H. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
4. Notify DEDC, LLC of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Shop Drawings: Indicate dimensions and components for each fixture that is not a standard product of the manufacturer.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
1. LED Luminaires:
a. Include estimated useful life, calculated based on IES LM-80 test data.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Conform to requirements of NFPA 70 and NFPA 101.

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.

B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.8 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

B. Provide five year manufacturer warranty for all LED luminaires, including drivers.

C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

A. Furnish products as indicated in luminaire schedule included on the drawings.

B. Substitutions: See Section 01 6000 - Product Requirements, except where individual luminaire types are designated with substitutions not permitted.

2.2 LUMINAIRES

A. Provide products that comply with requirements of NFPA 70.

B. Provide products that are listed and labeled as complying with UL 1598, where applicable.

C. Provide products that comply with requirements of NFPA 70 and NFPA 101.

D. Provide products listed, classified, and labeled as suitable for the purpose intended.

E. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

F. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.

G. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.

H. Recessed Luminaires:
   1. Ceiling Compatibility: Comply with NEMA LE 4.
   2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
   3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.

I. LED Luminaires:
   1. Components: UL 8750 recognized or listed as applicable.
   2. Tested in accordance with IES LM-79 and IES LM-80.
   3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

J. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

2.3 DRIVERS

A. Dimmable LED Drivers:
   1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
   2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.4 ACCESSORIES

A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.

B. Airplane cable: Steel Wire.

C. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.

D. Reflectors and installation trims for lighting fixtures to be installed in Armstrong specialty metal ceiling structures.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.

C. Verify that suitable support frames are installed where required.

D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

A. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of luminaires provided under this section.

B. Install products in accordance with manufacturer's instructions.

C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.

F. Suspended Ceiling Mounted Luminaires:
   1. Do not use ceiling tiles to bear weight of luminaires.
   2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
   3. Secure surface-mounted and recessed luminaires to building structure.
   4. Secure pendant-mounted luminaires to building structure.
   5. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
   6. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gage, connected from opposing corners of each recessed luminaire to building structure.
   7. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.

G. Recessed Luminaires:
   1. Install trims tight to mounting surface with no visible light leakage.
   2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
   3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.

H. Suspended Luminaires:
   1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
   2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
   3. Install canopies tight to mounting surface.
   4. Unless otherwise indicated, support pendants from swivel hangers.

I. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to bottom of luminaire.

J. Install fixtures securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting).

K. Install suspended luminaires using pendants supported from swivel hangers. Provide pendant length required to suspend luminaire at indicated height.

L. Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prevent movement.

M. Install accessories furnished with each luminaire.

N. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within fixture; use flexible conduit.

O. Connect luminaires to branch circuit outlets provided under Section 26 0537 using flexible conduit.

P. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

Q. Bond products and metal accessories to branch circuit equipment grounding conductor.

R. Install specified lamps in each luminaire.

3.4 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect each product for damage and defects.

C. Perform field inspection in accordance with Section 01 4000.

D. Operate each luminaire after installation and connection to verify proper operation.

E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by DEDC, LLC.

3.5 ADJUSTING

A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by DEDC, LLC. Secure locking fittings in place.

B. Aim and adjust fixtures as directed.

3.6 CLEANING

A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

B. Clean electrical parts to remove conductive and deleterious materials.

C. Remove dirt and debris from enclosures.

D. Clean finishes and touch up damage.

3.7 CLOSEOUT ACTIVITIES

A. See Section 01 7800 - Closeout Submittals, for closeout submittals.

B. Just prior to Substantial Completion, replace all fixtures that have failed, due to either, driver or LED board failure..

3.8 PROTECTION

A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Exterior luminaires.

B. Ballasts.

C. Poles and accessories.

D. Luminaire accessories.

1.2 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.

B. Section 26 0526 - Grounding and Bonding for Electrical Systems.

C. Section 26 0529 - Hangers and Supports for Electrical Systems.

D. Section 26 0533.16 - Boxes for Electrical Systems.

E. Section 26 0919 - Enclosed Contactors: Lighting contactors.

F. Section 26 0923 - Lighting Control Devices: Automatic controls for lighting including outdoor motion sensors, time switches, and outdoor photo controls.

1.3 REFERENCE STANDARDS

A. IEEE C2 - National Electrical Safety Code; 2017.

B. IES LM-79 - Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products; 2008.

C. IES LM-80 - Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules; 2015, with Errata (2017).

D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

E. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems; 2006.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. UL 1598 - Luminaires; Current Edition, Including All Revisions.

H. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
   2. Notify DEDC, LLC of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Shop Drawings:
   1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
   2. Provide photometric calculations where luminaires are proposed for substitution.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.
   1. LED Luminaires:
      a. Include estimated useful life, calculated based on IES LM-80 test data.

1.6 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.

B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.8 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

B. Provide five year manufacturer warranty for all LED luminaires, including drivers.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

A. Furnish products as indicated in luminaire schedule included on the drawings.

B. Substitutions: See Section 01 6000 - Product Requirements.

2.2 LUMINAIRES

A. Provide products that comply with requirements of NFPA 70.

B. Provide products that are listed and labeled as complying with UL 1598, where applicable.

C. Provide products listed, classified, and labeled as suitable for the purpose intended.

D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.

F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.

G. Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.

H. LED Luminaires:
   1. Components: UL 8750 recognized or listed as applicable.
   2. Tested in accordance with IES LM-79 and IES LM-80.
   3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

2.3 BALLASTS AND DRIVERS

A. Ballasts/Drivers - General Requirements:
   1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
   2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.

2.4 POLES

A. All Poles:
   1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.

2. Material: Steel, unless otherwise indicated.
3. Shape: Round straight, unless otherwise indicated.
4. Finish: Match luminaire finish, unless otherwise indicated.
5. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.

2.5 ACCESSORIES

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.

C. Verify that suitable support frames are installed where required.

D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

A. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of luminaires provided under this section.

B. Install products in accordance with manufacturer's instructions.

C. Install luminaires in accordance with NECA/IESNA 501.

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.

F. Recessed Luminaires:
1. Install trims tight to mounting surface with no visible light leakage.
2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.

G. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to bottom of luminaire.

H. Pole-Mounted Luminaires:
   1. Maintain the following minimum clearances:
      a. Comply with IEEE C2.
      b. Comply with utility company requirements.
   2. Foundation-Mounted Poles:
      a. Provide cast-in-place concrete foundations for poles as indicated, in accordance with Section 03 3000.
         1) Install anchor bolts plumb per template furnished by pole manufacturer.
         2) Position conduits to enter pole shaft.
      b. Install foundations plumb.
      c. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
      d. Tighten anchor bolt nuts to manufacturer's recommended torque.
      e. Install non-shrink grout between pole anchor base and concrete foundation, leaving small channel for condensation drainage.
      f. Install anchor base covers or anchor bolt covers as indicated.
   3. Grounding:
      a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
   4. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.

I. Install accessories furnished with each luminaire.

J. Bond products and metal accessories to branch circuit equipment grounding conductor.

3.4 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Inspect each product for damage and defects.

C. Operate each luminaire after installation and connection to verify proper operation.

D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by DEDC, LLC.

3.5 CLEANING

A. Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

A. See Section 01 7800 - Closeout Submittals, for closeout submittals.

B. Just prior to Substantial Completion, replace all fixtures, due to either, driver or LED board failure..

3.7 PROTECTION

A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

SECTION 27 1000 - DATA & VOICE COMMUNICATIONS CABLING

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. Data & Voice Communications Cabling Standards
   2. Wire management systems
   3. Closet hardware

B. Related Sections: The following sections contain requirements that relate to this section:
   1. Division 16 Electrical Materials and Methods sections.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for the following products:
   1. Cable
   2. Data & Voice jacks and faceplates
   3. Wire management systems for both Data & Voice
   4. Closet hardware for both Data & Voice
   5. Data Racks

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver closet hardware in original packaging to provide protection during transit and job storage.

B. Store and handle cable and hardware to prevent damage during construction.

PART 2 PRODUCTS & MANUFACTURERS

2.1 AVAILABLE MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, THE FOLLOWING PRODUCTS MAY BE INCORPORATED IN THE WORK:

2.2 PLENUM CATEGORY 6E CABLE

A. 23 AWG, 4 pair, White for Voice & Data
   1. Commscope Part # 7504 (1000 ft. reel)
   2. Commscope Part # 7504 (1000 ft. tote box)
   3. HITACHI Part # 30183-8 (1000 ft. reel)

4. HITACHI Part # 30183-8 (1000 ft. tote box)
5. Hubbell Part # C6SPW (1000 ft. reel)
6. Hubbell Part # C6RPW (1000 ft. tote box)

B. Cable Colors:
1. Blue for Data Communication
2. White for Voice Communication

2.3 CATEGORY 6 DATA & VOICE JACKS

A. Hubbell Part #HXJ6EI
1. T568B, Electrical Ivory

B. Or approved Equal

2.4 FACEPLATES FOR DATA & VOICE

A. Hubbell Part # IFP14EI (4 Port Plate)
1. IFP PLATES SINGLE-GANG Electrical Ivory

B. Or approved Equal

C. Hubbell Part # P630SR1GC6
1. Recessed 8-position Category 6, gray jack, RJ45
2. Only for wall phones

D. Or approved Equal

2.5 BLANK DUST COVERS FOR FACEPLATES

A. Hubbell Part # SFBE10

B. Or approved Equal

2.6 BLANK DUST COVERS FOR DATA & VOICE JACKS

A. Hubbell Part # HXJDC25

B. Or approved Equal

2.7 FULL-SIZE RACK SYSTEMS FOR DATA

A. Chatsworth Part #55053-503
1. 84" high standard E1A 19" Rack

B. Or approved Equal

2.8 HUBBELL MULTIMEDIA PATCH PANELS CATEGORY 6

A. Hubbell 48 Port Patch Panel XCELERATOR Part # UDX48E1U

B. CAT 6 data jacks shall be Hubbell Part #HXJ6EI

C. 110 patch panels (24, 48 or 96 ports) are not to be used

D. If there are any questions, contractors must call the I.T. Network Analyst assigned to the project.

E. Or approved Equal

2.9 HUBBELL MULTIMEDIA PANELS CATEGORY 6

A. Hubbell 48 Port Patch Panel XCELERATOR Part # UDX48E1U

B. Or approved Equal

2.10 HUBBELL CATEGORY 6 HINGED FOLD DOWN PANELS

A. Hubbell 48 Port Patch Panel Part # P648UF (Wall Mount)

B. Hubbell 48 Port Patch Panel Part # P648UF19 (Rack Mount)

C. Or approved Equal

2.11 WIRE MANAGEMENT FOR RACK SYSTEMS

A. Hubbell Horizontal Wire Manager Part # HC319CE6N

B. Chathsworth Vertical Cable Manager Part # 35521-703

C. Cablofil E-Z TRAY Cable Management Part # CF 54/300 EZ

D. Cablofil Wall Termination Bracket Part # HB2

E. Cablofil FAS Profile Part # FAS-P300

F. Or approved Equal

2.12 VOICE TERMINATION BLOCKS

A. One Nordx-GigaBIX -Nordx #AX-101470 for station cables

B. One Nordx-GigaBIX 300 pair Cat 6 BIX frame kit for riser feeds Part # AX101471

C. Nordx-CDT GigaBIX (12) 25 pair connector - Part #AX101448

D. part # AX101472(1) mount

E. part # AX101483 (6) designation strips

F. part # AX101486 (12) wire guards

G. Or approved Equal

2.13 TERMINATION TOOLS

A. Punch Down Tool with 110 Blade, BIX Blade & 66 Blade.
   1. When terminating on the new Hubbell CAT 6 jacks for both DATA & VOICE, the tools of choice is: PUNCH-DOWN TOOL,(1-PUNCH) Part number - HUBBELL TX4P.
   2. Or approved Equal

2.14 WALL/FLOOR/DECKING PENETRATION FIRE RATED PATHWAY (EZ-PATH)

A. Single Series 44 Pathway Through Finished Walls
   1. Part Number EZDP44
      a. Single Wall Plate Kit is designed to allow a single Series 44 Pathway to be installed in a 6 in. (152 mm) round opening or 4-1/8 in (105 mm) x 4-5/8 in (118 mm) opening.
   2. Or approved Equal

B. Multiple or Ganged Pathway Installations
   1. Part Number EZP544W
      a. Multi-Gang Wall Brackets are designed to allow 1 to 5 Series 44 Pathways to be installed in finished walls or as the wall is being built. Plates attach directly to studs and pathways are installed prior to application of gypsum board. Brackets are suitable for attachment to studs spaced up to 24 in. (610 mm). Single Wall Plate Kit is designed to allow a single Series 44 Pathway to be installed in a 6 in. (152 mm) round opening or 4-1/8 in (105 mm) x 4-5/8 in (118 mm) opening.
   2. Or approved Equal

C. NOTE: Ordering Details
   1. • Plate packs include plates, gaskets, set screws and labels.
   2. • Purchase Pathways (EZD44) and appropriate fasteners separately.

PART 3 EXECUTION

3.1 EXAMINATION

A. Prior to starting work, examine condition of site and existing hardware already in place with Owner's Representative present. Check all existing lines and levels indicated. Report any discrepancies with the construction documents, in writing, to the Owner's Representative.

3.2 CONTRACTOR QUALIFICATIONS AND TRAINING

A. The Contractor shall be fully conversant and capable in the cabling of low voltage applications such as, but not limited to data, voice and imaging network systems. The Contractor shall at a minimum possess the following qualifications:
   1. Possess those licenses/permits required to perform both Data & Telecommunications installations in the specified jurisdiction.
   2. Provide references of the type of installation provide in this specification.
   3. Personnel knowledgeable in local, state, province and national codes, and regulations. All work shall comply with the latest revision of the codes or regulations. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.
   4. Be in business a minimum of five (5) years.
   5. Must possess current liability insurance certificates.

3.3 INSTALLATION OF WALL/FLOOR/DECKING PENETRATION

A. Contractor shall provide and install approved Penetration Firestop Sleeve System. All data, video, and communications cable bundles shall utilize an enclosed fire rated pathway device wherever said cables penetrate rated walls. The fire-rated pathway shall contain a built-in fire sealing system sufficient to maintain the hourly fire rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to adjust, remove or reinstall firestop materials.

3.4 INSTALLATION OF CABLING

A. Contractor shall provide and install data & voice cables from device jack to specified data termination closet. Contractor shall terminate cables at both ends and clearly label both ends with Owner's numbering system.

B. Materials to be furnished may be subject to inspection at the factory, in the warehouse or in the field by the Owner's Representative or by qualified inspectors retained by the Owner's Representative.

C. Install all elements of the data & voice communications system in accordance with Division 16 Basic Materials and Methods Sections.

D. All Category 6 data wiring to be installed in accordance with IEEE/EIA/TIA 802.3 standards for 100 BASE-TX.

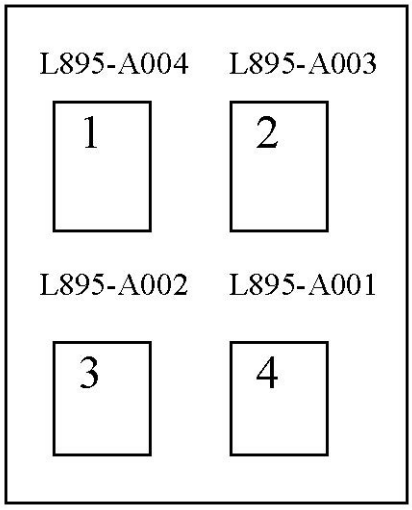
E. All Category 6 voice wiring will be installed in accordance with Telephone and Communications Industry Standards.

F. All UTP and fiber optic cables shall conform to ANSI/TIA/EIA-568-B Commercial Building Telecommunications Cabling Standard (latest amendment and including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).

G. All communications wiring shall be installed in a 5” square 2 7/8” deep back box with a single gang tile ring, with a 1-1/4" conduit stubbed above the ceiling, not to exceed four per conduit and four jacks per box. Any additional wiring shall require additional conduit and back boxes. Again not to exceed four wires per conduit and per back box.

3.5 LABELING FOR DATA

A. Each new wire should be labeled as follows; closet # - patch panel letter - port # (Example: 6131-A-001). Labels shall be located 1/4"-1" from both ends of each wire. The jack faceplate of each new wire shall be similarly labeled. The contractor shall also label the front of each patch panel port with a P-TOUCH label showing the room number of the corresponding jack. The Owner's Representative will provide the closet number, patch panel letter(s) and available patch panel port numbers.



3.6 LABELING FOR VOICE

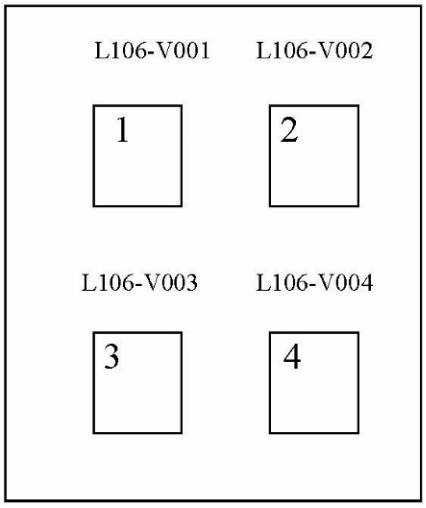
A. Device outlets (FACEPLATES) are to be labeled with the closet number and followed by a hyphen then letter “V” followed by cable number. (Example:L106-V001, 2, 3, etc.)

B. Terminal BIX blocks in the closet are to be labeled with room number and followed by hyphen then letter “V” followed by cable number. (Example:L856-V001, 2, 3, etc.)

C. Wire labels shall be located 1/4"-1" from both ends of the cable with the closet number and cable number (Example:L106-V001).
   1. (Example:L106-V001)

Bix Block

L856-V001	L856-V002				



3.7 TESTING FOR DATA

A. Each installed twisted pair cable shall be tested, using a Fluke/Microtest DPS-4300 series or OMNIScanner2. When running the AUTO TEST feature the following test will executed, Length, Attenuation, Near End Crosstalk (NEXT) Loss, Power Sum Near-End Crosstalk (PSNEXT) Loss, Equal Level Far-End Crosstalk (ELFEXT),Power Sum Equal Level Far-End Crosstalk (PSELFEXT), Return Loss, Propagation Delay (ANSI/TIA/EIA-568-B-1), Longitudinal Conversion Loss (LCL), Attenuation to Crosstalk Ratio (ACR), Power Sum Attenuation to Crosstalk Ratio (PSACR) from both ends. Each circuit number will be identified using the same labeling scheme as required on the jack faceplate. Test results will be provided to the Owners Representative in both hard copy and soft copy on CD as specified in the Reports section. The Contractor may propose an equivalent testing method by submitting full documentation thereof for review by the Owner's Representative.

B. All Category 6 channels are qualified for linear transmission performance up to 300 MHz to ensure that high-frequency voltage phase and magnitude contributions do not prove cumulative or adversely affect channel performance.

C. All UTP field testers shall be factory calibrated each calendar year by the field test equipment manufacturer as stipulated by the manuals provided with the field test unit. The calibration certificate shall be provided for review prior to the start of testing.

D. Autotest settings provided in the field tester for testing the installed cabling shall be set to the default parameters.

E. Test settings selected from options provided in the field testers shall be compatible with the installed cable under test.

3.8 TESTING FOR VOICE

A. Testing for voice wires will consist of wire map and continuity.

3.9 JACK TERMINATIONS

A. Hubbell quad wall jack plate shall be used whenever a new wire for data & voice jacks are required, unless specified otherwise. If there is an existing data & voice jack within two feet of the new jack location, the existing data & voice jack shall be upgraded to a Hubbell quad wall jack.

B. Sockets 1 and 2, in that order, will normally be occupied by voice (telephone) connections. Sockets 4 and 3, in that order, will normally be the data positions on the quad jack. If 6 port single gang plate is required data will start in position 6 and work backwards. If there is no need for voice connections, positions 2 and 1, in that order, may be used for data jacks but only at the discretion of the Owner's Representative.

C. Data Termination
   1. Use RJ45-TIA/EIA-568-B Configurations
   2. NO SPLITTING OF PAIRS, one jack equals one cable

D. Voice Termination
   1. Use RJ45-TIA/EIA-568-B Configurations
   2. NO SPLITTING OF PAIRS, one jack equals one cable

PART 4 ADMINISTRATION DOCUMENTATION

4.1 DRAWINGS

A. As-built drawing shall be supplied by the contractor showing the locations of and identifiers for all:
   1. Horizontal cable routing and terminations
   2. Telecommunications outlets/connectors
   3. Backbone cable routing and terminations

4.2 REPORTS

A. All wires installed in the project shall be tested and documented with the completed documentation being turned over to the Owners Representative with all As Built Documentation.

4.3 DATA TEST RESULTS

A. Each data wire will be tested as specified in Section 3.6. Each record must contain the identifier as specified in Labeling Section.3.4. Final results will be provided in both hard copy and soft copy format, preferably CD.

4.4 VOICE TEST RESULTS

A. Each voice wire will be tested as specified in Section 3.7. Each record must contain the identifier as specified in Labeling Section 3.5. The final voice report shall be in hard copy and soft copy format preferably CD.

END OF SECTION

SECTION 28 3111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

RELATED DOCUMENTS

1.1 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. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. System Carbon Monoxide detectors
5. System Combination Smoke/ Carbon Monoxide detectors.
6. Duct Smoke detectors
7. Notification appliances.
8. Addressable interface device.
9. Digital alarm communicator transmitter.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. NICET: National Institute for Certification in Engineering Technologies.

D. PC: Personal computer

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.
1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.
1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
3. Include battery-size calculations.
4. Include input/output matrix.
5. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.

6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:
   1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
   2. Shop Drawings shall be prepared by persons with the following qualifications:
      a. Trained and certified by manufacturer in fire-alarm system design.
      b. NICET-certified, fire-alarm technician; Level III minimum.
      c. Licensed or certified by authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
      b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
      c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
      d. Riser diagram.
      e. Device addresses.
      f. Record copy of site-specific software.
      g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
         1) Equipment tested.
         2) Frequency of testing of installed components.
         3) Frequency of inspection of installed components.
         4) Requirements and recommendations related to results of maintenance.
         5) Manufacturer's user training manuals.
      h. Manufacturer's required maintenance related to system warranty requirements.
      i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

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.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys and Tools: One extra set for access to locked or tamperproofed components.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
   1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
   2. Warranty Period: Five years from date Certificate of Occupancy is granted.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

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

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:
   1. Manual stations.
   2. Smoke detectors.
   3. Carbon Monoxide detectors

4. Duct Smoke detectors
5. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Record events in the system memory.
5. Shutdown respective air handling systems.
6. Turn-on all occupancy controlled egress lighting to 100% output.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
2. Ansul System operation.
3.

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 communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:
1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciator.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 FIRE-ALARM CONTROL UNIT

A. Manufacturers:
1. Silent Knight IntelliKnight.
2. Notifier.
3. Or approved equal.

B. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
b. Include a real-time clock for time annotation of events on the event recorder and printer.
c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
d. The FACP shall be listed for connection to a central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

D. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, two line(s) of 40 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
1. Pathway Class Designations: NFPA 72, Class B.
2. Pathway Survivability: Level 0.
3. Install no more than 50 addressable devices on each signaling-line circuit.
4. Serial Interfaces:
a. One dedicated RS 485 port for central-station operation using point ID DACT.
b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
c. One USB port for PC configuration.

F. Notification-Appliance Circuit:
1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

I. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, supervisory, and digital alarm communicator transmitters shall be powered by 24-V dc source.
   1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
   1. Batteries: Sealed lead calcium.

K. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

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.
   1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
   1. Comply with UL 268; operating at 24-V dc, nominal.
   2. Detectors shall be two-wire type.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

6. Integral Visual-Indicating Light: LED type, indicating detector has operated.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition.

B. Photoelectric Smoke Detectors:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
a. Primary status.
b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

2.6 SYSTEM CARBON MONOXIDE DETECTORS

A. General Requirements for System Carbon Monoxide Detectors:
1. Comply with UL2075; operating at 24V dc, nominal.
2. Detectors shall be two wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition.

B. Carbon Monoxide Detectors:
1. Carbon Monoxide detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. Carbon Monoxide detector shall be capable of providing a temp 4 notification pattern for CO alarm indication.
3. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
a. Primary Status.
b. Device Type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.)

2.7 COMBINATION SMOKE AND CARBON MONOXIDE DETECTOR

A. General Requirements for System Carbon Monoxide Detectors:
   1. Comply with UL2075 & UL268 for CO detection.
   2. Uses only one address on the signaling line circuit.
   3. Combination detector shall allow for separate supervisory and alarm signals for the two different detection types.
   4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   5. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   6. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   7. Integral Visual-Indicating Light: LED type, indicating detector has operated.
   8. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition.

B. Combination Smoke and Carbon Monoxide Detectors:
   1. Sensor: The detector shall be a combination smoke and carbon monoxide utilizing four sensing technologies including photoelectric, infrared, heat and carbon monoxide.
   2. Capable of providing temp 3 pattern for fire alarm notification and temp 4 pattern for carbon monoxide alarm notification.
   3. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary Status.
      b. Device Type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.)

2.8 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

B. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
   1. Rated Light Output:
      a. 15/30/75/110 cd, selectable in the field.
   2. Mounting: Wall mounted unless otherwise indicated.
   3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   4. Flashing shall be in a temporal pattern, synchronized with other units.
   5. Strobe Leads: Factory connected to screw terminals.
   6. Mounting Faceplate: Factory finished, white.

2.9 DUCT SMOKE DETECTORS:

A. Comply with UL268A. Provide relay to close smoke dampers.

2.10 ADDRESSABLE INTERFACE DEVICE

A. General:
   1. Include address-setting means on the module.
   2. Store an internal identifying code for control panel use to identify the module type.
   3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
   1. Allow the control panel to switch the relay contacts on command.
   2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:
   1. Operate notification devices.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Digital alarm communicator transmitter shall be an IP-DACT type.

C. 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 or dial out on VOIP, as coordinated with AHJ. 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.

D. 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.

E. Digital data transmission shall include the following:
   1. Address of the alarm-initiating device.
   2. Address of the supervisory signal.
   3. Address of the trouble-initiating device.
   4. Loss of ac supply.
   5. Loss of power.
   6. Low battery.
   7. Abnormal test signal.
   8. Communication bus failure.

F. Secondary Power: Integral rechargeable battery and automatic charger.

G. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
   1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
   1. Devices placed in service before all other trades have completed cleanup shall be replaced.
   2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

C. Manual Fire-Alarm Boxes:
   1. Install manual fire-alarm box where indicated within 60 inches of the exit doorway.
   2. Mount manual fire-alarm box on a background of a contrasting color.
   3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

D. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

E. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

F. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

3.3 PATHWAYS

A. Pathways shall be installed in red EMT. EMT on upper floors shall not be exposed.

3.4 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
   1. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
   2. Ansul system.

3.5 IDENTIFICATION

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

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect and authorities having jurisdiction.

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

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Visual Inspection: Conduct visual inspection prior to testing.
      a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
      b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
   2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
   3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
   4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
   5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
   6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization.

Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Equipment vendor shall provide a One (1) year fire alarm monitoring contract starting at sign off of completion of project by owner. Equipment vendor shall also provide a pricing plan to owner for an optional 2 year extension contract for monitoring after the one year contract is completed.

C. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

D. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. The training class shall be run for 4 hours.

END OF SECTION

SECTION 31 2316.13 - TRENCHING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Backfilling and compacting for utilities outside the building to utility main connections.

1.2 DEFINITIONS

A. Finish Grade Elevations: Indicated on drawings.

1.3 REFERENCE STANDARDS

A. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18 in.) Drop; 2018.

B. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)); 2012, with Editorial Revision (2015).

C. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN m/m3)); 2012, with Editorial Revision (2015).

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used.

C. Compaction Density Test Reports.

1.5 DELIVERY, STORAGE, AND HANDLING

A. When necessary, store materials on site in advance of need.

B. When fill materials need to be stored on site, locate stockpiles where indicated.
   1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
   2. Prevent contamination.
   3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. General Fill: Conforming to State of Maryland Public Works Department standard.

2.2 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for general requirements for testing and analysis of soil material.

B. Where fill materials are specified by reference to a specific standard, test and analyze samples for compliance before delivery to site.

C. If tests indicate materials do not meet specified requirements, change material and retest.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that survey bench marks and intended elevations for the work are as indicated.

3.2 PREPARATION

A. Identify required lines, levels, contours, and datum locations.

B. Locate, identify, and protect utilities that remain and protect from damage.

C. Notify utility company to remove and relocate utilities.

D. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

E. Protect plants, lawns, rock outcroppings, and other features to remain.

F. Grade top perimeter of trenching area to prevent surface water from draining into trench. Provide temporary means and methods, as required, to maintain surface water diversion until no longer needed, or as directed by the DEDC, LLC.

3.3 TRENCHING

A. Notify DEDC, LLC of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

B. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.

C. Do not interfere with 45 degree bearing splay of foundations.

D. Cut trenches wide enough to allow inspection of installed utilities.

E. Hand trim excavations. Remove loose matter.

F. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.

G. Remove excavated material that is unsuitable for re-use from site.

H. Remove excess excavated material from site.

I. Provide temporary means and methods, as required, to remove all water from trenching until directed by the DEDC, LLC. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack of dewatering or surface water control.

J. Determine the prevailing groundwater level prior to trenching. If the proposed trench extends less than 1 foot into the prevailing groundwater, control groundwater intrusion with perimeter drains routed to sump pumps, or as directed by the DEDC, LLC.

3.4 PREPARATION FOR UTILITY PLACEMENT

A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.

B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.

C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

3.5 BACKFILLING

A. Backfill to contours and elevations indicated using unfrozen materials.

B. Employ a placement method that does not disturb or damage other work.

C. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.

D. Maintain optimum moisture content of fill materials to attain required compaction density.

E. Soil Fill: Place and compact material in equal continuous layers not exceeding 8 inches compacted depth.

F. Slope grade away from building minimum 2 inches in 10 feet, unless noted otherwise. Make gradual grade changes. Blend slope into level areas.

G. Correct areas that are over-excavated.
   1. Other areas: Use general fill, flush to required elevation, compacted to minimum 97 percent of maximum dry density.

H. Compaction Density Unless Otherwise Specified or Indicated:
   1. At other locations: 95 percent of maximum dry density.

I. Reshape and re-compact fills subjected to vehicular traffic.

3.6 BEDDING AND FILL AT SPECIFIC LOCATIONS

A. Use general fill unless otherwise specified or indicated.

B. Utility Piping and Conduits:
   1. Bedding: Use general fill.
   2. Cover with general fill.
   3. Fill up to subgrade elevation.
   4. Compact in maximum 8 inch lifts to 95 percent of maximum dry density.

3.7 TOLERANCES

A. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.8 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for general requirements for field inspection and testing.

B. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D1557 ("modified Proctor"), AASHTO T 180, or ASTM D698 ("standard Proctor").

C. If tests indicate work does not meet specified requirements, remove work, replace and retest.

3.9 CLEANING

A. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.

END OF SECTION

SECTION 33 7119 - ELECTRICAL UNDERGROUND DUCTS, DUCTBANKS, AND MANHOLES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Conduit and duct:
   1. Rigid polyvinyl chloride (PVC) conduit.
   2. Polyvinyl chloride (PVC) plastic utilities duct.

B. Accessories:
   1. Underground warning tape.

1.2 RELATED REQUIREMENTS

A. Section 03 1000 - Concrete Forming and Accessories.

B. Section 03 2000 - Concrete Reinforcing.

C. Section 03 3000 - Cast-in-Place Concrete.

D. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.

1.3 REFERENCE STANDARDS

A. ASTM F512 - Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation; 2012 (Reapproved 2017).

B. IEEE C2 - National Electrical Safety Code; 2017.

C. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2013.

D. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2016.

E. NEMA TC 6&8 - Polyvinyl Chloride (PVC) Plastic Utilities for Underground Installations; 2013.

F. NEMA TC 9 - Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation; 2004 (Reaffirmed 2012).

G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

H. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide for nonmetallic conduit.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 CONDUIT AND DUCT

A. Rigid Polyvinyl Chloride (PVC) Conduit: NFPA 70, Type PVC; comply with NEMA TC 2 and list and label as complying with UL 651; Schedule 40 unless otherwise indicated; rated for use with conductors rated 90 degrees C.
   1. Fittings: Comply with NEMA TC 3 and list and label as complying with UL 651.
      a. Manufacturer: Same as manufacturer of conduit to be connected.

B. Polyvinyl Chloride (PVC) Plastic Utilities Duct: Comply with NEMA TC 6&8 and ASTM F512; Type EB-20 listed and labeled as complying with UL 651, suitable for burial with concrete encasement.
   1. Fittings: Comply with NEMA TC 9.
      a. Manufacturer: Same as manufacturer of duct to be connected.

2.2 ACCESSORIES

A. Underground Warning Tape: Polyethylene tape suitable for direct burial.
   1. Manufacturers:
      a. Brady Corporation; _____: www.bradyid.com/#sle.
      b. Brimar Industries, Inc; _____: www.brimar.com/#sle.
      c. Seton Identification Products; _____: www.seton.com/#sle.
      d. Substitutions: See Section 01 6000 - Product Requirements.
   2. Foil-backed Detectable Type Tape: 3 inches wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.
   3. Legend: Type of service, continuously repeated over full length of tape.
   4. Color:
      a. Tape for Buried Power Lines: Black text on red background.
      b. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

2.3 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify routing and termination locations of duct bank prior to excavation for rough-in.

C. Duct bank routing is shown in approximate locations unless dimensions are indicated. Route as required to complete duct system.

3.2 DUCT BANK INSTALLATION

A. Install duct to locate top of ductbank at depths as indicated on drawings.

B. Install duct with minimum slope of 4 inches per 100 feet (0.33 percent). Slope duct away from building entrances.

C. Cut duct square using saw or pipe cutter; de-burr cut ends.

D. Insert duct to shoulder of fittings; fasten securely.

E. Wipe nonmetallic duct dry and clean before joining. Apply full even coat of adhesive to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

F. Install no more than equivalent of three 90-degree bends between pull points.

G. Provide suitable fittings to accommodate expansion and deflection where required.

H. Use suitable separators and chairs installed not greater than 4 feet on centers.

I. Band ducts together before backfilling.

J. Securely anchor duct to prevent movement during concrete placement.

K. Provide suitable pull string in each empty duct except sleeves and nipples.

L. Swab duct. Use suitable caps to protect installed duct against entrance of dirt and moisture.

M. Interface installation of underground warning tape with backfilling. Install tape 12 inches below finished surface.

END OF SECTION