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SECTION 21 05 00
COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for piping materials and fittings, mechanical sleeve seals, sleeves, escutcheons, grout, fire suppression demolition, concrete bases, and supports and anchorages, and common installation instructions for piping systems.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 02 41 00, Demolition
2. Section 03 05 15, Portland Cement Concrete
3. Section 05 50 00, Metal Fabrications
4. Section 07 84 00, Firestopping
5. Section 22 05 00, Common Work Results for Plumbing

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society of Mechanical Engineers (ASME)
   a. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
   b. ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
   c. ASME B31.1 Power Piping
   d. ASME B31.3 Process Piping

   a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   b. ASTM B32 Standard Specification for Solder Metal
   c. ASTM B813 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
   d. ASTM B828 Standard Practice for Making Capillary Joints By Soldering of Copper and Copper Alloy Tube and Fittings
3. American Welding Society
   a. AWS A5.8 Specification for Filler Metals for Brazing and Bronze Welding
   b. AWS D1.1 Structural Welding Code Steel
   c. AWS D10.12 Guide for Welding Mild Steel Pipe

1.03 DEFINITIONS
A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.04 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Welding certificates.

1.05 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."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
C. All equipment and component assemblies furnished and installed on the fire suppression system shall be UL listed and FM approved for its specific use.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Pipe, Tube and Fittings

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

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

B. Joining Material

1. Refer to individual Section 21 10 00 Water-Based Fire-Suppression System for special joining materials not listed below.

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


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


C. Mechanical Sleeve Seals

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

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

3. Pressure Plates: Stainless steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

D. Sleeves

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

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

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

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

E. Escutcheons
1. 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.

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

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

4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

F. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   b. Design Mix: 5000-psi, 28-day compressive strength.
   c. Packaging: Premixed and factory packaged.

G. Flexible Expansion Joint

1. Description: 175 psig rating, UL Listed flexible loop capable of 4-inches movement in three planes and consisting of two flexible sections of hose and stainless steel braid, two 90-degree bends and one 180-degree return bend with hanger support nut and drain/air release plug. Bends and end connections shall be consistent with piping system specified in Section 21 10 00, "Water-Based Fire Suppression Systems". Provide MetraFlex Fireloop or equal.

PART 3 - EXECUTION

3.01 ERECTION

A. Metal Supports and Anchorages

1. Refer to Section 05 50 00, Metal Fabrications, for structural steel.

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

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

B. Wood Supports and Anchorages

1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor fire suppression materials and equipment.
2. 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.

3. Attach to substrates as required to support applied loads.

3.02 INSTALLATION

A. Piping Systems

1. Install piping according to the following requirements and as indicated.

2. 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. Drawing Plans do not indicate entire pipe system. Contractor is responsible to develop complete system layout and design using indicated piping locations and sizing.

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

4. 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.

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

6. Install piping to permit valve servicing.

7. Install piping at indicated slopes.

8. Install piping free of sags and bends.

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

10. Install piping to allow application of insulation.

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

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

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


   a. Install steel pipe for sleeves smaller than 6 inches in diameter.

   b. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
c. 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.

15. 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.

a. 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.

16. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 00, Firestopping, for materials.

17. Verify final equipment locations for roughing-in.

18. Refer to equipment specifications in other Sections herein for roughing-in requirements.

19. Install flexible expansion joints where indicated on drawings and where piping crosses building seismic joints. Install vertical support hanger within 4 pipe diameters on each side of the flexible joints and seismic joint. Brace each hanger longitudinally and transversely. Install vertical support at 180-degree return bend.

3.03 APPLICATION

A. Grouting

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

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

3. Provide forms as required for placement of grout.

4. Avoid air entrapment during placement of grout.

5. Place grout, completely filling equipment bases.

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

7. Place grout around anchors.

8. Cure placed grout. In accordance with manufacture recommendations

3.04 CONSTRUCTION

A. Piping Joints
1. Join pipe and fittings according to the following requirements and Division 21, Fire Suppression, Sections specifying piping systems.

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

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


6. 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:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
   a. Do not use pipe sections that have cracked or open welds.

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

B. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to the seismic performance requirements of Section 21 10 00, Water-Based Fire-Suppression Systems. The requirements of Section 21 10 00 shall take precedent.
   a. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated or required by seismic design analysis, install dowel rods on 18-inch centers around the full perimeter of the base.
   c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
e. Install anchor bolts to elevations required for proper attachment to supported equipment.

f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

g. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 05 15, Portland Cement Concrete.

END OF SECTION
SECTION 21 05 13
COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

PART 1 - GENERAL

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

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. National Electrical Manufacturers Association (NEMA)
      a. NEMA MG-1 Motors and Generators, Includes Errata and Revision 1

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

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in fire suppression equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.

2.02 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 104 degrees F and at altitude of 3300 feet above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
2.03 POLYPHASE MOTORS

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

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.


F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.05 SINGLE-PHASE MOTORS

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

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

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

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

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

PART 3 - EXECUTION (NOT USED)

END OF SECTION
SECTION 21 05 17
SLEEVES AND SLEEVE SEALS FOR FIRE PIPING

PART 1 - GENERAL

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

1.02 REFERENCES
   A. ASTM A53
   B. ASME B36.10

1.03 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 SLEEVES
   A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-
      iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
   B. Galvanized-Steel Wall Pipes: ASTM A53/A 53M, Schedule 40, with plain ends and
      welded steel collar; zinc coated.
   C. Galvanized-Steel-Pipe Sleeves: ASTM A53/A 53M, Type E, Grade B, Schedule 40, zinc
      coated, with plain ends.
   D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed
      with welded longitudinal joint.

2.02 STACK-SLEEVE FITTINGS
   A. Manufacturers: Subject to compliance with requirements, available manufacturers
      offering products that may be incorporated into the Work include, but are not limited to,
      the following:
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

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

1. Underdeck Clamp: Clamping ring with setscrews.

2.03 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

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

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

2.04 SLEEVE-SEAL FITTINGS

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

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

1. Presealed Systems.

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

2.05 GROUT


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

C. Design Mix: 5000-psi, 28-day compressive strength.
PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

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

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

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

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

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.

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

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

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

D. Install sleeves for pipes passing through interior partitions.

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

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

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00, Joint Sealants.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in 07 84 00, Firestopping.

3.02 STACK-SLEEVE-FITTING INSTALLATION

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

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00, Sheet Metal Flashing and Trim.

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

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

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 00, Firestopping.

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.04 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
a. **Piping Smaller Than NPS 6**: Cast-iron wall sleeves with sleeve-seal system.
   
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. **Piping NPS 6 and Larger**: Cast-iron wall sleeves with sleeve-seal system.
   
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. **Concrete Slabs above Grade**:
   
   a. **Piping Smaller Than NPS 6**: Galvanized-steel-pipe sleeves Stack-sleeve fittings.
   
   b. **Piping NPS 6 and Larger**: Galvanized-steel-pipe sleeves Stack-sleeve fittings.

5. **Interior Partitions**:
   
   a. **Piping Smaller Than NPS 6**: Galvanized-steel-pipe sleeves.
   
   b. **Piping NPS 6 and Larger**: Galvanized-steel-sheet sleeves.

**END OF SECTION**
SECTION 21 10 00
WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following fire-suppression systems in or connected to the Station.
   1. Automatic wet-type, Class 1 standpipe system for the stairwells
   2. Completion of the Automatic wet-type Class 1 standpipe system for the connecting tunnels.
   3. Wet-pipe sprinkler systems
   4. Dry pipe sprinkler systems
   5. Pre-action sprinkler systems.

B. This section includes engineering requirements for hydraulic calculations and fire-suppression systems supports.

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 09 90 00, Painting and Coating
   2. Section 10 44 00, Fire Protection Specialties
   3. Section 21 05 00, Common Work Results for Fire Suppression
   4. Section 21 08 00 Commissioning for Fire Protection
   5. Section 22 11 16, Domestic Water Piping
   6. Section 22 11 19, Domestic Water Piping Specialties
   7. Section 22 14 13, Facility Storm Drainage Piping
   8. Section 26 05 25, Wire and Cable
   9. Section 26 05 26, Grounding and Bonding for Electrical Systems
   10. Section 28 31 00, Fire Detection and Alarm

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American National Standards Institute (ANSI)
a. B16.3 Malleable Iron Threaded Fittings
b. B16.5 Pipe Flanges and Flanged Fittings
c. B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
d. B31.1 Power Piping

2. American Society of Mechanical Engineers International (ASME)
a. Boiler and Pressure Vessel Code (BPVC), Section IX, Welding and Brazing Qualifications

3. American Society for Testing and Materials International (ASTM)
a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
b. ASTM A105 Standard Specification for Carbon Steel Forgings for Piping Applications
c. ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
d. ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
e. ASTM A183 Standard Specification for Carbon Steel Track Bolts and Nuts
f. ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength
g. ASTM A536 Standard Specification for Ductile Iron Castings
h. ASTM A563 Standard Specification for Carbons and Alloy Steel Nuts
i. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
j. ASTM B16 Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
k. ASTM B633 Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

4. City of Seattle (COS):
a. Seattle Fire Code (International Fire Code with Seattle Amendments and all applicable Administrative Rules)

5. Manufacturers Standardization Society for the Valve and Fittings Industry
a. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
b. MSS SP-69 Pipe Hangers and Supports – Selection and Applications
c. MSS SP-89 Pipe Hangers and Supports – Fabrications and Installation Practices

d. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports

6. National Fire Protection Association (NFPA)

a. NFPA 13 Standard for Installation of Sprinkler Systems
b. NFPA 14 Installation of Standpipe and Hose Systems
c. NFPA 25 Inspection Testing & Maintenance of Water-based Fire Protection Systems
d. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail

1.03 SYSTEM DESCRIPTIONS

A. Automatic Wet-Type, Class 1 Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand. PRV style hose valves shall have Seattle Fire Department compatible 2-1/2 inch hose connections on the supply valves provided for use by the fire department only.

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

C. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

D. Pre-action Sprinkler System: Automatic sprinklers are attached to piping containing air. Actuation of fire-detection system in same area as sprinklers opens deluge valve, permitting water to flow into piping and to discharge from sprinklers that have opened.

E. Deluge Sprinkler System: Open sprinklers are attached to piping connected to water supply through deluge valve. Fire-detection system, in same area as sprinklers, opens valve. Water flows into piping system and discharges from attached sprinklers when valve opens.

1.04 PERFORMANCE REQUIREMENTS

A. Fire-suppression standpipe system design shall provide for the following:

1. Minimum Residual Pressure at Each Hose-Connection Outlet: 100 psig.

2. Unless otherwise indicated, the Following Is maximum acceptable Residual Pressure at nominal flow through each Hose-Connection Outlet: 175 psig.

B. Fire-suppression sprinkler system design shall provide for the following:

1. Margin of Safety for available pressure at design water flow conditions: A 10 psi reserve “cushion between the available water supply pressure and hydraulically calculated pressure at system design demand, is required.
2. Sprinkler Occupancy Hazard Classifications: Indicated on the Contract Drawings in matrix form for each type of sprinkler system. Any areas not specifically identified on the Contract Drawings shall comply with the following:
   a. Building Service Areas: Ordinary Hazard, Group 1.
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   e. Platform Areas: Ordinary Hazard Group 2
   f. Public Areas: Ordinary Hazard Group 1

3. Minimum Density for Automatic-Sprinkler Piping Design: As Indicated on the Contract Drawings in matrix form for each type of sprinkler system. Any areas not specifically identified on the drawings shall comply with the following:
   a. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm/sq. ft. over the most remote 1500 sq. ft.
   b. For dry pipe and double interlock preaction systems, the area of sprinkler operation shall be increased by 30 percent without revising the density.

4. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 120 sq. ft.
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:
   a. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

C. Seismic Performance: Fire-suppression piping and support system shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13 and ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

D. Pressure Transient Loading: Fire-suppression piping and support systems at the platform level shall be capable of withstanding a transient pressure load of 0.10 pounds per square inch.

1.05 PROJECT COORDINATION

A. See Section 01 31 13, Project Coordination and Section 21 05 00, Common Work Results for Fire Suppression, for requirements.
1.06 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. All product data, shop drawings, and calculations required by this section shall be approved by the Seattle Fire Department.

C. Product Data: For each type of equipment/product, pipe, valve, pipe hanger, anchorage device and support system component.

D. Certified Test Reports: Submit certified test reports on the Contractor’s Material and Test Certificate for Aboveground Piping as shown in NFPA 13

E. Hydraulic Calculations: Submit hydraulic calculations for review prior to fabrication of all of the systems, signed and sealed by the qualified professional fire protection engineer registered in the State of Washington.
   1. Complete hydraulic agent flow calculations from a UL listed computer calculation program. Calculation sheets must include the software licenses name and the UL listing number for verification. Calculations shall include fill time requirements for dry pipe sprinkler systems.
   2. Hydraulic calculations shall include information from Hydrant flow test data acceptable to the Seattle Fire Department.
   3. Arrange with Seattle Public Utilities for hydrant flow test to be witnessed by Sound Transit and the Seattle Fire Department and submit complete Fire Hydrant flow test report.
   4. Contractor shall document Fire Department boost requirements to operate standpipe and sprinkler systems.

F. Shop Drawings, and Manufacturers’ product data including piping, fittings, valves, couplings, fire department connections, piping supports, maintenance data, and recommended spare parts. Show complete system in shop drawings, including construction phasing.
   1. Include design calculations for pipe supports and indicate size and characteristics of component and fabrication details.

G. Pipeline layout drawings together with standard details.
   1. Field installation layout drawings drawn to no less than 1/8”=1'-0” scale, prepared in accordance with NFPA 13 showing all sprinkler systems in plan view and including all accessories such as alarm valves, flow switches, drain valves and test connections.

H. Fire-Suppression Systems Support and Seismic Design Submittal: For pipe supports and seismic-restraint details to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional structural engineer registered in the State of Washington responsible for their preparation.
   1. Design Calculations: Calculate the seismic forces acting on the standpipe system(s) installed in this Contract and the sprinkler systems in the platform and station.
2. Design Analysis: The pipe supports are not detailed on the Contract Drawings. Submit detailed calculations for the design of the supports including seismic bracing, flow induced thrust bracing, and thermally induced pipe movement.

3. Seismic-Restraint and Support Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
   
a. Pre-approval and Evaluation Documentation: For seismic restraints devices selected. Documentation shall be prepared by an agency acceptable to Seattle Department of Planning and Development, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

I. Operation and Maintenance Manuals: Section 01 78 23, Operation and Maintenance Data. In addition to these requirements include manufacturer's installation and maintenance data for all fire suppression equipment/products furnished under this specification.

J. Welding Certificates.

K. Welding report interpreting weld radiographs to the Resident Engineer without recommendations.

1.07 QUALITY ASSURANCE

A. 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 B31.1 "Power Piping Code"

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

B. Employ shop and field welders and/or welding operators and welding procedures qualified in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

C. Employ a licensed fire protection installer to install and test the standpipe and sprinkler systems.

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

E. Seismic Design Engineering Responsibility: Preparation of working plans and calculations by a structural engineer registered in the State of Washington

F. Verify materials are clearly marked with the manufacturer's name, nameplate data or stamp, rating, and ASTM conformance number, as applicable.
   
1. Use only fire protection system components and equipment that is Underwriters Laboratories (UL) Listed and labeled and Factory Mutual (FM) approved for use in fire protection systems. All piping materials shall as a minimum conform to the requirements of NFPA 13.
PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. If acceptable manufacturers are not listed in this section, refer to the Articles describing each specific product type.

B. If it complies with these Contract Specifications and is UL listed and FM approved, for at least a 175 psig working pressure, except when higher pressure ratings are specified for the different piping components under their individual descriptions, one of the following pipe fitting manufacturers will be acceptable:

1. Screwed piping fittings, Class 150, ANSI B16.3 screwed malleable iron Class 125, ANSI B16.4 cast iron, or Class 150 ductile iron:
   a. Grinnell
   b. Star Products, Inc.
   c. Ward

2. Welding fittings ANSI B16.9 made of ASTM 234 Grade WPA or WPB steel with wall thickness identical to pipe in which installed:
   a. Babcock & Wilcox
   b. Grinnell
   c. Ladish
   d. Taylor Forge
   e. Tube-Line
   f. Tube-Turn
   g. Weld Bend

3. Flanges, Class 150, ANSI B16.5, raised face, forged steel, screwed or welding neck type where specified and/or required:
   a. Grinnell
   b. Ladish
   c. National Flange
   d. Taylor Forge
   e. Weld Bend

C. Weld fittings shall be UL listed and FM approved, factory made and shall be full line size. If it complies with these Contract Specifications, one of the following weld fitting manufacturers will be acceptable:

1. Branch pipes more than one size smaller than the diameter of the main pipe:
   a. Bonney Forge “Weldolet” or “Threadolet” ANSI B16.9
b. Grinnell Forged Steel Weldolet or Threadolet ANSI B16.9

c. “Weldolet”, “Threadolet” and Merit fittings and shaped nipples shall have a wall thickness as required by the ANSI B31.1.0 and ANSI 36.10 Code and shall be suitable for the working pressure and temperature of the pipe to which they connect.

2. For branch sizes 3 inches and smaller shaped nipple welding fittings with factory beveled ends:

a. Allied Type T-1 and T-2

b. Grinnell

c. Tube Forgings

d. Tube-Turn

e. Wheeling

f. Do not make any branches by burning a hole in the main and welding in the branch line.

D. If it complies with these Contract Specifications and is UL listed and FM approved, one of the following pipe hanger and support manufacturers will be acceptable:

1. B-Line

2. Grinnell

3. Hilti

4. Michigan Hanger

5. PHD

6. Tolco

E. At the Contractor’s option, grooved style couplings and fittings may be used in lieu of welded or screwed joints specified hereinbefore as follows:

1. For Sprinkler Loop and Branch Piping: Use Victaulic Style 005 or Grinnell 7400 UL listed, painted ductile iron couplings for roll groove on Schedule 10 and higher steel pipe. Pipe couplings to 8 inches in size shall be listed for a minimum of 300 psig working pressure.

2. For the Sprinkler Main Piping and the Stairwell Standpipe system: Use Victaulic Style 07 “Zero Flex”, or Gruvlok 7401 couplings with roll groove on Schedule 10 pipe or rolled or cut grooves on Schedule 40 pipe. Couplings to 8 inches size shall be listed for a minimum 450 psig working pressure.

3. For the Tunnel Standpipe System: Use only Victaulic Style 07 or Gruvlok 7401 couplings with roll or cut grooves on schedule 40 pipe. Victaulic Style 77 flexible couplings are acceptable only where added flexibility is necessary. Use with hot dip galvanized pipe where exposed in the unconditioned platform areas.

4. Fittings for the Standpipe & Sprinkler systems: UL listed, FM approved painted ductile iron Victaulic or Gruvlok standard grooved fittings or Victaulic “Firelock”
fitting compatible for use with the specified coupling and of pressure rating at least equal to that of the connected grooved coupling. Victaulic Style 920 mechanical tees are acceptable for use on Schedule 40 sprinkler branch piping. Fittings for use on the galvanized tunnel standpipe system are to be furnished hot dip galvanized from the factory.

5. Additional Requirements: Grooved fitting manufacturer shall be ISO 9001 approved.
   
a. Pipe grooves shall be made by a tool manufactured by the grooved coupling/fitting company. The manufacturer shall provide a certified letter with the Shop Drawing stating that the roll or cut grooving machine and fittings will provide a system complying with the pressure class and piping materials herein specified. Manufacturers groove depth control tool shall be used for field and shop grooving of piping. Manufacturer’s hole cutting tool shall be used in lieu of burning a hole in the piping. Gaskets shall be UL listed for the service and working pressure of the systems. Adapter flanges, reducing couplings and outlet couplings shall not be allowed. Couplings and fittings installed throughout the project shall be the product of one manufacturer. Factory-formed cut groove ends shall be provided for galvanized dry pipe systems.

F. If it complies with these Contract Specifications and is UL listed and FM approved, one of the following flange gasket manufacturers will be acceptable:

1. Crane
2. Dallas Gasket
3. Garlock

G. If it complies with these Contract Specifications and is UL listed and FM approved, check valves manufactured by one of the following manufacturers will be acceptable:

1. Crane
2. Grinnell
3. Kennedy
4. Mueller
5. Nibco
6. Victaulic
7. Viking

H. If it complies with these Contract Specifications and is UL listed and FM approved, gate valves manufactured by one of the following manufacturers will be acceptable:

1. Mueller
2. Crane
3. Croker
4. Fairbanks
5. Grinnell
6. Jenkins
7. Kennedy
8. Milwaukee
9. Nibco
10. Viking
11. Walworth

I. If it complies with these Contract Specifications and is UL listed and FM approved, butterfly valves manufactured by one of the following manufacturers will be acceptable:
   1. Grinnell
   2. Jenkins
   3. Milwaukee
   4. Nibco
   5. Victaulic

J. If it complies with these Contract Specifications and is UL listed and FM approved, floor control valves manufactured by one of the following manufacturers will be acceptable:
   1. Croker
   2. Elkhart “Pressure-Matic”
   3. Guardian
   4. Potter-Roemer
   5. Standard “Pressuretrol”
   6. Zurn

K. If it complies with these Contract Specifications, specialty valves such as alarm check valves, deluge, dry pipe valves and double interlocked preaction sprinkler systems (or single interlocked preaction sprinkler system) manufactured by one of the following manufacturers will be acceptable:
   1. Tyco
   2. Victaulic
   3. Grinnell
   4. Notifier
   5. Reliable Sprinkler Company
   6. Viking Corp
2.02 STEEL PIPE & FITTINGS

A. Piping 4 inches and smaller shall be ASTM A 53, ASTM A 135 or ASTM A 795 black steel for all wet pipe systems as specified herein. Dry pipe and pre action systems shall be galvanized. Pipe shall be manufactured in the United States.

B. Piping 6 inches and larger shall be ASTM A 53, Grade B, ASTM A 135 or ASTM A 795 black steel Type “S” (seamless), Type “F” (furnace-butt welded) or Type “E” (electric resistance welded). Electric resistance welded pipe shall be fully normalized at the seams after welding. Pipe shall be manufactured in the United States.

C. Pipe wall thickness shall be in accordance with ANSI B36.10, current edition and shall be as follows:

1. For the standpipe systems:
   a. Schedule 40, hot-dip galvanized for the tunnel standpipe system
   b. Schedule 10 or Schedule 40, black steel painted for the stairwell system

2. For 175 psig wet loop and branch pipe of the sprinkler systems:
   a. 1 inch through 2 inches: Schedule 40
   b. 2-1/2 through 6 inches: Schedule 10 or Schedule 40

3. For the 175 psig wet feed mains to the sprinkler systems:
   a. 2-1/2 through 6 inches Schedule 10 or Schedule 40

4. For 175 psig on all dry pipe systems including pre-action systems:
   a. Schedule 40
   b. Piping shall be galvanized in accordance with ASTM A123

D. Fire protection systems utilizing Schedule 40 pipe to be of threaded below 2 inches in size, and of butt welded or cut or roll groove construction above 2 inches in size. Do not use roll groove construction on dry pipe systems. Shop welds on sub assemblies of pipe to be hot dip galvanized after fabrication.

E. Flanges are required for servicing and/or removal of equipment for repair in butt welded systems. Schedule 10 pipe to be joined by roll grooved fittings only.

F. At each joint the flanges to have matching flat faces or raised faces, and the flanges shall be identified in configuration and pressure rating. Steel flanges shall have a medium tool finish and shall have either flat or raised faces. When 150 lb. steel flanges are connected to 125 lb. cast iron or 300 lb. ductile iron flanges valves or fittings, the steel flanges shall be flat face medium finish. Grooved flange adapters shall be Victaulic 741 or Gruvlok Fig. 7012 using flange washers to join to the rubber faced serrated flanged components or raised faced flanges. Serrated flanges or raised face flanges shall use a full face red rubber gasket between the grooved flange washer and the flange to provide an acceptable sealing surface.

G. Screw joints to be made up with approved pipe joint compound. Screw threads are to be in accordance with American Pipe Thread Standards.
H. Flange gasket material to be as specified herein and must also be suitable for the service and pressure class intended.

1. Gaskets to be 1/16 inch thick for all pipe sizes 10 inch and smaller; and 1/8 inch thick for all pipe sizes 12 inch and larger. Gaskets shall be ring type between raised face flanges and full face type between flat face flanges with punched bolt holes and pipe opening.

2. Gaskets to be compressed non-asbestos with a nonstick clean surface and factory applied parting agent applied to both sides of the gasket.

3. Gaskets to contain no asbestos.

I. Flange bolting materials for flanges in service at 399 degrees F or below to be carbon steel ASTM A 307 Grade B hexagon head bolts and nuts. Cap screws utilized with flanged butterfly valves shall be ASTM A 307 Grade B cap screws with hexagon heads. Flange bolt thread lubricant shall be an antiseize compound. Thread lubricant designed for temperatures up to 1000 degrees F, shall be Crane Antiseize Thread Compound or approved equal. Where the configuration or arrangement of flanges prevent the installation of machine bolts, stud bolts are an acceptable alternate.

2.03 DUCTILE-IRON PIPE AND FITTINGS

A. Limit use restrained mechanical joint ductile iron pipe or mechanical joint sleeve to extending the 10-inch underground water supply from just outside the building to a few feet inside the building. Use grooved end ductile iron pipe to extend the pipe aboveground to the backflow preventer in the South Fire Services Room inside the building.

B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151 cement lined, Class 53 with mechanical-joint bell end and plain end.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern.

2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron restraining glands, rubber gasket, and stainless steel bolts and nuts.

C. Grooved-End, Ductile-Iron Pipe: AWWA C151 cement lined Class 53, with factory- or field-formed, radius-cut-grooved ends according to AWWA C606.

1. Grooved-Joint Piping Systems:
   a. Manufacturers:
      1) Victaulic Co. of America.
      2) Gruvlok from Anvil International Inc.
   b. Grooved-End Fittings: ASTM A 536, ductile-iron casting with OD matching AWWA ductile-iron-pipe OD.
   c. Grooved-End-Pipe Couplings: AWWA C606, gasketed fitting matching ductile-iron-pipe OD. Include ductile-iron housing with keys matching ductile-iron-pipe and fitting grooves, prelubricated rubber gasket with center leg, and steel bolts and nuts. Coupling shall be rated for 350 psig minimum working pressure.
d. Grooved-End Transition Coupling: UL and FM approved ductile iron coupling for connecting grooved end IPS steel pipe, valves or fittings to grooved end AWWA ductile iron pipe. Furnish complete with flush seal gasket. Coupling shall be rated for 350 psig minimum working pressure.

e. Grooved-End Transition Flange Adapter: UL 213, gasketed fitting with key for ductile-iron-pipe dimensions designed for direct connection of flanged components into a radius grooved AWWA ductile iron piping system. Include flange-type, ductile-iron housing with rubber gasket listed for use with housing and complete with steel bolts and nuts.

2.04 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed or FM approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping.

B. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.

1. Manufacturers:
   a. Central Sprinkler Corp.
   b. Fire-End and Croker Corp.
   c. Viking Corp.
   d. Victaulic Co. of America.

C. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.

1. Manufacturers:
   b. Fire-End and Croker Corp.
   c. Potter-Roemer; Fire-Protection Div.

D. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.

1. Manufacturers:
   a. AGF Manufacturing Co.
   b. Central Sprinkler Corp.
   c. G/J Innovations, Inc.
   d. Triple R Specialty of Ajax, Inc.

E. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.

1. Manufacturers:
   a. CECA, LLC.
b. Merit.

2.05 LISTED FIRE-PROTECTION VALVES

A. Valves shall be UL listed or FM approved, with minimum pressure rating as specified below. If pressure rating is not specified minimum acceptable rating is 175 psig.

B. Refer to Part 3 Article "Valve Applications" and Contract Drawings for fire isolation valves (FIV) and system drainage (DRV) valves.

C. Ball Valves 2-inch NPS and smaller: Provide ball valves for drain service and where show on the Contract Drawings of size as indicated. Where low point drains are not indicated, provide a minimum size drain and ball valve as required by NFPA 13 and 14 respectively for the Sprinkler and Standpipe systems


   b. Ball Valve: UL Listed and FM approved and rated for 600 psi water-oil-gas (WOG)

      1) Where used for other than drain service provide Indicating Type Ball Valves: UL 1091, with integral indicating device and ends matching connecting piping. Indicator: Provide with pre-wired, single-circuit, supervisory switch suitable for installation in a 115 V-AC electrical system.

   c. Manufacturers:

      1) Global Safety Products, Inc.
      2) Milwaukee Valve Company.
      3) Watts Regulator

D. Butterfly Valves 2-1/2-inch NPS and larger: Lug type with grooved ends. Designed for fire protection service with grooved ends, polyphenylene sulfide blend coated ductile iron body. Disc shall be ductile iron conforming to ASTM A536 with electrolysis nickel coating conforming to ASTM B-733. Furnish with nitrile (Grade T) seat conforming to ASTM D2000. Use only valves UL Listed for minimum 300 psi service in fire protection systems. Furnish valve with gear operated actuator and hand wheel. Actuator shall have bronze traveling nut on a steel lead screw contained in a ductile iron housing. Valve shall have a black alkyd enamel coating. Furnish complete with two single-pole double-throw (SPDT) supervisory switches factory wired to junction box. UL 1091.

   a. Manufacturers:

      1) McWane, Inc.; Kennedy Valve Div.
      2) Mueller Company.
      3) NIBCO.
      4) Pratt, Henry Company.
5) Victaulic Co. of America.

E. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.

1. Manufacturers: As listed in Article 2.01, herein

F. Gate Valves: UL 262, OS&Y type.

1. NPS 2 and Smaller: Gate valves up to and including 2 inch size Kennedy Figure 66, 175 psig cold water, UL listed, bronze body, bronze trim, single disc, outside screw and yoke, screwed bonnet valves with seats of bronze, screwed ends.

   a. Other Acceptable Manufacturers:

      1) Crane Co.; Crane Valve Group; Crane Valves.

      2) Hammond Valve.

      3) NIBCO.

2. NPS 2-1/2 and Larger: Gate valves 2-1/2-inch through 10-inch, Kennedy Figure 4068, 175 psig cold water, UL listed and approved iron body, outside screw and yoke bolted bonnet valves with double or single disc, Class 125 ANSI B16.1 flanged ends, bronze trim, bronze seats.

   a. Other Acceptable Manufacturers: As listed in Article 2.01, herein.

2.06 SPECIALTY VALVES

A. Deluge Valves (ALV):

1. UL 260, hydraulically operated, differential-pressure type. Include trim set for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection. Include a wet, pilot-line trim set with gage to read push-rod chamber pressure, bobe valve for manual operation of deluge valve, and connection for actuation device.

B. Dry Pipe System:

1. Dry Pipe Valves (ALV):

   a. Dry pipe and pre action valves shall be equal to Victaulic NXT with low pressure regulator (or approved equal) to reduce water delivery time.

   b. Provide where indicated a dry pipe valve equipped to give a signal upon operation, complete with standard trimmings, including water and air pressure gauges, test by-pass and necessary piping, fittings and accessories required for a complete installation. All dry piping to be Schedule 40 galvanized pipe. Do not use roll groove fittings on dry pipe systems.

   c. Arrange all dry pipe systems so that they can be fully drained.

   d. Provide pressure alarm switch. Electric connection to the Fire Alarm Panel will be by Division 26, Electrical.
e. Provide a low air pressure trouble switch. Field electric connection will be by Section 28 31 00, Fire Detection and Alarm. Switch will alarm at the Fire Alarm Panel. Coordinate switch requirements with the work provided in 28 31 00.

2. Dry Pipe Compressors: Dry pipe system air compressors shall be furnished. Compressors shall be sized to fill the piping system to the required pressure in 30 minutes. Each compressor shall be automatically controlled by a factory mounted pressure switch. In addition, provide a separate low pressure switch with set point lower than the operating switch to provide a trouble signal to the Fire Alarm Panel. Coordinate switch requirements with the work provided in Section 28 31 00, Fire Detection and Alarm. Compressor electrical requirements shall be suitable for the voltage provided. The Contractor shall provide the following data with his bid proposal:

   a. Location of each dry pipe air compressor.
   b. Motor horsepower and voltage requirements for each air compressor.

C. Alarm Check Valves (ALV): UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.

   a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
   b. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

D. Automatic Drain Valves: UL 1726, NPS 3/4, ball-check device, straight or angle pattern with threaded ends. Valve is used to drain low point of system between fire department connection and swing check valve. Seals automatically under pressure

   1. Manufacturers:
      a. AFAC Inc.
      b. Grinnell Fire Protection.
      c. Potter Roemer

2.07 SPRINKLERS

A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating.

B. Manufacturers:

   1. AFAC Inc.
   2. Central Sprinkler Corp.
   3. Firematic Sprinkler Devices, Inc.
   5. Grinnell Fire Protection.
   6. Reliable Automatic Sprinkler Co., Inc.
7. Star Sprinkler Inc.
9. Victaulic Co. of America.
10. Viking Corp.

C. Automatic Sprinklers: With heat-responsive element complying with the following:
   1. UL 199, for nonresidential applications.
   2. UL 1767, for early-suppression, fast-response applications.

D. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.

E. Sprinkler types, features, and options as follows:
   1. Concealed ceiling sprinklers, including cover plate.
   2. Flush ceiling sprinklers, including escutcheon.
   3. Pendent sprinklers.
   4. Quick-response sprinklers.
   5. Recessed sprinklers, including escutcheon.
   7. Upright sprinklers.

F. Sprinkler Finishes: Chrome plated, bronze, and painted.

G. Special Coatings: Wax, lead, and corrosion-resistant paint.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
   2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

I. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.08 FIRE HOSE OUTLET VALVES

A. Fire Hose Valves (FHV) are for use by the Fire Department and are installed on the standpipe system(s).
   1. 2-1/2 inch angle type cast brass; with a rough chrome plated finish, and valve rated to 300 psi. Furnish with red hand wheel, female National Pipe Taper (NPT) inlet and the Seattle Fire Department compatible male hose thread outlet.
      a. Verify that valve is UL Listed and FM approved and furnish complete with brass cap and chain. Use fire hose valves of Elkhart Brass Model No. U-
25%-25 or approved equal by Kidde Fire Fighting or the Waterous Company.

2. 2-1/2 inch angle type valve for use on high pressure standpipes to control nozzle pressure; cast brass construction with a rough chrome plated finish, valve rated to 400 psi inlet pressure. Valve shall operate automatically depending on inlet pressure and flow. Furnish with red hand wheel, female National Pipe Taper (NPT) inlet and the Seattle Fire Department compatible male hose thread outlet.
   a. Verify that valve is UL Listed and FM approved and furnish complete with brass cap and chain. Use fire hose valves of Elkhart Brass Model No. UR-25-2.5 or approved equal by Kidde Fire Fighting or the Waterous Company.
   b. Valves shall be factory based on the residual inlet pressure and be capable of flowing 300 gpm at inlet pressures greater than 175 psig and less than 400 psig, with outlet residual pressures between 170 psig and 130 psig at the 300 gpm delivered flow.

2.09 FIRE DEPARTMENT CONNECTIONS

A. Manufacturers:
   1. AFAC Inc.
   2. Central Sprinkler Corp.
   4. Fire-End and Croker Corp.
   5. Fire Protection Products, Inc.
   8. Potter-Roemer; Fire-Protection Div.
   9. Reliable Automatic Sprinkler Co., Inc.
   10. United Brass Works, Inc.

B. Wall-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass chrome plated inlets, brass wall chrome plated escutcheon plate, brass chrome lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching the Seattle Fire Department threads, outlet with pipe threads, extension pipe nipples for each inlet, check devices or clappers for inlets, and escutcheon plate with raised letters at least 1-inch in size with marking similar to "CH STATION AUTO SPKR & STANDPIPE." for two of four flush FDCs and “SOUTH TUNNEL STANDPIPE” and “NORTH TUNNEL STANDPIPE” respectively for the other two.
   1. Type: Flush, with four inlets and square or rectangular escutcheon plate and with 6 inch outlet connection orientation as shown on the Contract Drawings
2.10 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm: UL 753, mechanical-operation type with pelton-wheel operator with shaft length, bearings, and sleeve to suit wall construction and 10-inch-diameter, cast-aluminum alarm gong with red-enamel factory finish. Include NPS 3/4 inlet and NPS 1 drain connections.

1. Manufacturers:
   a. AFAC Inc.
   b. Central Sprinkler Corp.
   c. Firematic Sprinkler Devices, Inc.
   d. Globe Fire Sprinkler Corporation.
   e. Grinnell Fire Protection.
   f. Reliable Automatic Sprinkler Co., Inc.
   g. Star Sprinkler Inc.
   h. Viking Corp.

C. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.

1. Manufacturers:
   a. ADT Security Services, Inc.
   b. Grinnell Fire Protection.
   c. ITT McDonnell & Miller
   d. Potter Electric Signal Company.
   e. System Sensor.
   f. Viking Corp.
   g. Watts Industries, Inc.; Water Products Div.

D. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

1. Manufacturers:
   a. McWane, Inc.; Kennedy Valve Div.
   b. Potter Electric Signal Company.
2.11 MANUAL SPRINKLER VALVE
   A. Manual Sprinkler Valve (MSV): UL listed or FMG approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.12 CONTROL PANELS
   A. Description: Single-area, two-area, or single-area cross-zoned type control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.

2.12 1. Panels: UL listed and FMG approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
2. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and a cover held closed by breakable strut.

2.13 PRESSURE GAGES
   A. Manufacturers:
      1. AGF Manufacturing Co.
      2. AMETEK, Inc.; U.S. Gauge.
      5. Marsh Bellofram.
      6. WIKA Instrument Corporation.
   B. Description: UL 393, 3-1/2- to 4-1/2-inch diameter, dial pressure gage with range of 0 to 250 psig minimum.
      1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
      2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

2.14 SELF-CONTAINED PREACTION SPRINKLER SYSTEM UNITS
   A. Description: Supply and install an integrated fire protection system, preaction fail-safe type, as indicated, including the preaction cabinet, automatic sprinkler system and fire detection system. The integrated unit shall be UL Listed and FM Approved as an assembled unit. All system components shall be "compatible", UL Listed or FM Approved.
B. NOTE: The word “compatible” used in this specification means that the items concerned have been tested and listed and/or approved for their use together.

C. Components:

1. Preaction Cabinet with Deluge Valves (PASCV): Supply and install a fail-safe preaction cabinet containing all hydraulic and electrical components required for the control of a preaction system. The cabinet shall include a sturdy 14-gauge steel cabinet, measuring with control panel 71"x36"x20" (180x91x51cm) for 1-1/2", 2" & 3" systems and 71"x46"x24" (180x117x61cm) for 4" & 6" systems. The cabinet shall have a textured rustproof coating, inside and outside, fire red, oven baked polyester powder on phosphate base. The cabinet shall have individual access doors for the hydraulic and electrical sections and the emergency release with a neoprene gasket to avoid vibrations. The preaction system components shall include the Deluge Valve Model, complete with Schedule 40 galvanized steel EZ-Trim rated at 250 PSI, integrated control panel, with emergency battery backup, the field wiring terminal strips integrated with the cabinet for connection of field wiring for detection system, audible devices, auxiliary contacts and power supply for control panel and air compressor, the pressure gauges to indicate water supply pressure, priming water pressure and air pressure of the system, each actuation and supervisory device required, a Schedule 40 steel pipe header with grooved ends to be connected to supply water and a Schedule 40 steel pipe drain manifold of 2" diameter for drain connections. Open drain cups in the cabinet and multiple drain manifolds will not be accepted.

2. Accessories:
   a. Automatic and supervised air supply of sufficient capacity to fill the system in the prescribed time with air compressor isolation switch and control pressure switch.
   b. Listed and approved integrated supervised discharge by-pass valve installed in the cabinet, with sight glass assembly on drain to visually confirm discharge.
   c. The cabinet assembly must be pre-assembled, pre-wired and factory tested under ISO-9001 conditions. It shall also be UL Listed and FM Approved as an assembled unit.
   d. Smoke detectors must be compatible and approved to be used with the system control panel. Most heat detectors are of the dry contact type and can work with almost any kind of control panel whereas smoke or flame detectors are designed with standards that are specific to each manufacturer and then cannot work with every, or all, control panels. Additionally, each manufacturer is producing different categories or generations of detectors that are not necessarily compatible between each other, further compounding the potential problems. The detection system should be adapted to the normal operating conditions of the hazard protected and should allow for a faster detection of the fire condition than the automatic sprinklers. Furthermore, it shall not cause false alarms due to the type of occupation.

3. Detection and Signaling System: Supply and install a complete electrical detection system including the system tubing, wiring, smoke detectors, signaling devices and connections to auxiliary functions. The heat and/or smoke detectors can be wired on one zone for operation in single zone mode. When used for smoke detectors, this zone shall consist of a combination of photoelectric and
ionization detectors on a 1:1 ratio. The heat and/or smoke detectors and the
alarm indicating devices (24 Vdc bell, horn or strobe) must be compatible with
the integrated Release Control Panel.


5. Air Supply: The automatic sprinkler piping is supervised by air from a
compressed air source installed inside the preaction cabinet. The air supply
must be regulated and of the proper size in order to be able to restore normal
system air pressure within 30 minutes.

6. Piping: System piping and fittings shall be as recommended by NFPA 13.

7. By-Pass Valve and Sight-Glass Assembly: The system shall be provided with a
UL Listed and FM Approved integrated by-pass butterfly valve installed on the
system riser inside the cabinet for full flow test purposes. The valve shall also be
surprised. An integrated sight glass shall be part of this arrangement for
visually confirm water flow upon system actuation. Detailed instructions placard
must be provided inside the cabinet.

8. System Drain: The single drain collector of the system shall be connected to an
open drain. The drain piping shall not be restricted or reduced and shall be of
the same diameter as the drain collector. Multiple drain collectors and open
drain cups inside the cabinet will not be accepted. Manifolding of multiple units is
permitted provided the manufacturer’s recommendations are carefully followed
and complied with.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS, GENERAL

A. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and
pressure ratings same as or higher than the specified products pressure rating may be
used in aboveground applications shown on the Contract Drawings, subject to approval
by the Resident Engineer.

B. Piping between Fire Department Connections and Check Valves: Galvanized, Schedule
40 steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and
grooved joints.

C. Underground Service-Entrance Piping: Ductile-iron, mechanical-joint pipe and fittings
and restrained joints.

D. Underground Service-Entrance Piping: Ductile-iron, grooved-end pipe and fittings;
grooved-end-pipe couplings; and grooved joints.

3.02 STANDPIPE SYSTEM PIPING APPLICATIONS

A. Grooved-end, black or galvanized, standard-weight steel pipe with square-cut- or roll
-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.03 SPRINKLER SYSTEM PIPING APPLICATIONS

A. NPS 1-1/2 and Smaller: Threaded-end, black or galvanized, standard-weight steel pipe;
cast- or malleable-iron threaded fittings; and threaded joints.
B. NPS 2 and Larger: Grooved-end, black or galvanized, standard-weight steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.04 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13 and NFPA 14. Unless valve type is called out on the Contract Drawings provide:
   a. Shutoff Duty or Fire Isolation Valves (FIV): Use butterfly or gate valves.
   b. System Drainage (DRV): Ball valves.

2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13 and NFPA 14. Unless valve type is called out on the Contract Drawings provide:
   a. Shutoff Duty: Use butterfly or gate valves.
   b. Throttling Duty: Use globe valves.

3.05 SERVICE ENTRANCE PIPING

A. Connect to the 10-inch below-ground water source just outside building as shown on the Contract Drawings.

B. Install supervised shutoff valve and pressure gage in each feed ahead of common tee connection, to allow for independent servicing of each water feed for the fire protection system.

C. For the buried pipe entrance(s) into the building, provide adequately sized galvanized sleeve cast in place in the wall and seal annual space between pipe and sleeve using modular rubber sealing unit. Coordinate with the information on mechanical sleeve seals under “Part 2-Products” of Section 21 05 00, Common Work Results for Fire Suppression.

3.06 STANDPIPE COMPONENT INSTALLATION

A. Install the standpipe systems as indicated, in accordance with requirements of NFPA 14.

B. Install standpipe piping so that it can be thoroughly drained and, where practicable, arranged to drain at the main drain valves.

C. Install pressure gages at top of each standpipe riser in the stairwells.

D. Valve accessibility for operation and servicing is required. Install valves as indicated and with no stems located below the horizontal position.

E. Provide escutcheon plates at finished surfaces where exposed piping passes through floors, walls, and ceilings. Fasten escutcheons to pipe or pipe coverings.

F. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14, the Seattle Fire Department and the approved pipeline layout drawings submitted in accordance with the paragraph titled “Submittals”.

G. Connect to the existing capped tunnel standpipe mains provided under the N125 contract.

H. Coordinate the installation of pipes, hangers, valves and all other items of the fire protection system with the work of all other trades so that all components will be installed to avoid conflicts and provide for proper servicing and maintenance of mechanical and electrical equipment in the ceiling plenums and equipment rooms.

3.07 SPRINKLER PIPING INSTALLATION

A. Refer to Section 21 05 00, Common Work Results for Fire Suppression, for basic piping installation.

B. Locations and Arrangements: Contract Drawing Plans, Schematics, and Diagrams indicate general location and arrangement of piping. Install piping as indicated, to implement the esthetic intent of the Contract Drawings.

1. Deviations from approved Contractor developed working plans for piping will require written approval from the Seattle Fire Department. File written approval with Resident Engineer before deviating from approved working plans.

2. Exposed piping shall be installed as nearly as possible parallel to or at right angles to the column lines of the building. Springing or forcing piping into place will not be permitted. Install piping in such a manner as to prevent strain on the equipment

C. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

D. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

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

F. Furnish and install all sleeves and fire proofing as required when penetrating inside walls and floors

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

H. Install sprinkler piping with drains for complete system drainage. Carefully grade piping so as to eliminate traps and pockets. Where traps cannot be avoided provide drains.

I. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

J. Install alarm devices and flow switches in piping systems as indicated on the Contract Drawings

K. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.

L. Install pressure gages on riser or feed main and at each sprinkler test connection. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe or ball valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
M. Coordinate the installation of pipes, hangers, valves and all other items of the fire protection system with the work of all other trades so that all components will be installed to avoid conflicts and provide for proper servicing and maintenance of mechanical and electrical equipment in the ceiling plenums and equipment rooms.

3.08 HANGER AND SUPPORT INSTALLATION:

A. Pipe hanger and support installation of the pre-engineered pipe hanger and seismic restraint system shall conform to the following:

1. Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure or the tunnel structure.

2. Design and space supports as indicated in NFPA 13 and ASCE 7. Comply with NFPA 13 for hanger material selection. Install additional supports for flow induced thrust and other concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms.

3. Install expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer’s written instructions.

4. Install hangers and supports and seismic bracing in accordance with NFPA 13 and ASCE 7, complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

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

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

7. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, “Building Services Piping,” are not exceeded.

8. All hangers and associated hardware in the unconditioned platform areas shall be hot-dip galvanized

3.09 CONSTRUCTION

A. Welding

1. Shop-fabricate all major piping assemblies.

2. Field welding, in general, is not permitted. In specific cases and only with the approval of the Resident Engineer may the Contractor be allowed to field-weld. Submit request to field weld with sufficient proof that no other method is feasible.

3. All welds shall have 100 percent penetration and smooth lines of fusion on the exterior and interior. Do not exceed 1/16-inch weld reinforcement.

4. Examine welds in accordance with the requirements of ANSI/ASW D1.1, Section 6, Parts A and B, and ASTM E94 and ASTM E1032, as applicable. In addition,
examine by radiography 100 percent of the welds that are embedded in concrete or buried and examine fully by random radiography a minimum of 10 percent of all remaining circumferential butt welds.

B. Repair of Galvanized Surfaces:

1. Clean welds, bolted connections, field cut grooved pipe, and abraded areas such as rolled grooves on galvanized pipe and apply galvanizing-repair paint in accordance with Section 05 05 13, Shop-Applied Coating for Metal.

3.10 SPRINKLER APPLICATIONS

A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types, in accordance with NFPA 13, Seattle Fire Department, and approved shop drawings and pipeline layout drawing submitted in accordance with paragraph titled “Submittals”:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Pendent sprinklers.
4. Sprinkler Finishes:
   a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
   b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
   c. Flush Sprinklers: Bright chrome, with painted white escutcheon.
   d. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.

3.11 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels and tiles. Architectural sensitive areas are shown on Contract Drawings including but not limited to the Architectural reflected ceiling plans.

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

3.12 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes, unless otherwise indicated.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install hose-connection valves with flow-restricting device, unless otherwise indicated.

D. Install wall-mounting-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Refer to Section 10 44 00, Fire Protection Specialties, for cabinets.
3.13 FIRE DEPARTMENT CONNECTION INSTALLATION
A. Install wall-type, fire department connections in vertical wall.
B. Install ball drip valve at each check valve for fire department connection.

3.14 CONNECTIONS
A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment to allow service and maintenance.
C. Connect water-supply piping to fire-suppression piping. Include backflow preventer between potable-water piping and fire-suppression piping. Refer to Section 22 11 19, Domestic Water Piping Specialties, for backflow preventers.
D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.
F. Electrical Connections: Power wiring is specified in Section 26 05 25, Wire and Cable.
G. Connect alarm devices to fire alarm.
H. Ground equipment according to Section 26 05 26, Grounding and Bonding for Electrical Systems.
I. Connect wiring according to Section 26 05 25, Wire and Cable.

3.15 LABELING AND IDENTIFICATION
A. Comply with the requirements of Section 22 05 50, Mechanical Identification, and install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14. In case of conflict the requirements of NFPA 13 & 14 will govern respectively for the Sprinkler & Standpipe systems unless otherwise allowed by the Seattle Fire Department.
1. Identify fire hose cabinets with lettering not less than 2 inches high.

3.16 PAINTING
A. Prepare piping system to be free from grease, oil, rust and scale, and make ready for the application of paint as specified in Section 09 90 00, Painting and Coating. Provide protective covering to keep paint away from the sprinkler heads; protective covering shall be removed under Section 09 90 00.

3.17 FIELD QUALITY CONTROL
A. Flushing of Piping: Underground mains and lead in connections to system risers shall be completely flushed before connection is made to sprinkler and standpipe piping. The minimum rate of flow shall not be less than that indicated in NFPA 13. All flushing water shall be disposed off in a manner acceptable to the Resident Engineer.
B. Testing (General)
1. Perform 100 percent visual inspection of all field welds.
2. Test installed systems and products hydrostatically, using testing instruments calibrated by an Independent Testing Laboratory in accordance with Section 01 45 00, Quality Assurance/Quality Control, and flush after removal of testing equipment in accordance with applicable requirements of NFPA 13 & NFPA 14 respectively. Repair leaks and retest repaired parts of both the existing and new sections of the systems. Repair damages resulting from the system's failure during the test at no additional cost to Sound Transit.

   a. Test standpipe hydrostatically for 2 hours without loss in pressure, using the most convenient outlet connection. The test pressures for the standpipe system are as follows:

      1) The stairwell standpipe system shall be tested with a 250 psig reading at the high point of the system.

   b. Test all sprinkler system piping and appurtenances subject to system working pressure using a minimum 290 psig test pressure that shall be maintained without loss for 2 hours.

   c. In addition to the hydrostatic tests the dry and pre-actions system are to be subjected to an air pressure leakage test for 24 hours using 40 psig air with less than 1-1/2 psi loss over the test period.

   d. Contractor shall provide and dispose of the quantity of water necessary for testing. Refer to Section 01 57 24, Temporary Site Water Discharge, for testing water disposal requirements.

   e. After testing, remove all water from wet and dry system. Fill wet systems for final acceptance when heat trace systems are operational or when directed by the Resident Engineer.

3. Conduct stairwell system flow test(s) in accordance with NFPA 14 including but not limited to the following:

   a. Flow 250 gpm from each of the two most remote hose valves in the stairwell to verify residual pressure(s) without pumper truck assist.

4. Furnish items used in testing

   a. Calibrate pressure gages.

   b. Use testing instruments calibrated by an Independent Testing Laboratory according with Section 00 45 00, Quality Assurance/Quality Control.

C. Perform tests in the presence of the Resident Engineer and Seattle Fire Department. Give 48-hour notice prior to test and notify the Seattle Fire Department and Seattle Public Utilities. The Resident Engineer will review certificates and test reports, and will inspect the standpipe and sprinkler system to verify conformance with Standards and other References in the Specifications including NFPA 14 and NFPA 13.

3.18 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Water Based Fire Suppression Systems and equipment. Refer to Section 21 08 00 Commissioning for Fire Protection.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 21 12 00
FIRE SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing, installing, and testing a partial standpipe system including, but not limited to wet standpipe piping, hangers and supports, fire hose valves (standpipes), automatic air vents, and sectionalizing valves.

B. The provisions of the Section do not cover the connection to the municipal water supply, backflow preventer, alarm valve, or the permanent fire department connections. This work will be provided by a separate contract.

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 45 00, Quality Assurance/Quality Control
2. Section 01 50 00, Temporary Facilities and Controls.
3. Section 01 78 23, Operation and Maintenance Data.
4. Section 01 57 24, Temporary Site Water Discharge
5. Section 01 01 13, Shop Applied Coating For Metal.
6. Section 05 50 00, Metal Fabrications
7. Section 21 05 00, Common Work Results for Fire Suppression.
8. Section 22 05 50, Mechanical Identification

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American National Standards Institute (ANSI)
   a. B16.3 Malleable Iron Threaded Fittings
   b. B16.5 Pipe Flanges and Flanged Fittings
   c. B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
   d. B31.1 Power Piping
2. American Society of Mechanical Engineers (ASME)
   a. Boiler and Pressure Vessel Code (BPVC), Section IX, Welding and Brazing Qualifications
3. American Society for Testing and Materials (ASTM)
   a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   b. ASTM A105 Standard Specification for Carbon Steel Forgings for Piping Applications
   d. ASTM A183 Standard Specification for Carbon Steel Track Bolts and Nuts
   e. ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength
   f. ASTM A536 Standard Specification for Ductile Iron Castings

4. City of Seattle (COS):
   a. Seattle Fire Code (International Fire Code with Seattle Amendments)

5. Manufacturers Standardization Society for the Valve and Fittings Industry
   a. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
   b. MSS SP-69 Pipe Hangers and Supports – Selection and Applications
   c. MSS SP-89 Pipe Hangers and Supports – Fabrications and Installation Practices
   d. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports

6. National Fire Protection Association (NFPA)
   a. NFPA 13 Standard for Installation of Sprinkler Systems
   b. NFPA 14 Installation of Standpipe and Hose Systems
   c. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: For each type of valve, pipe hanger, anchorage device and channel support system component.

C. Shop Drawings, and Manufacturers’ product data including piping, fittings, valves, couplings, fire department connections, piping supports, maintenance data, and recommended spare parts. Show complete system in shop drawings, including construction phasing.

D. Pipeline layout drawings together with standard details.

1. Show on the line layout each standard pipe joint and each special joint or fitting by number and each hanger or support.
E. Certified Test Reports on Contractor's Material and Testing for underground piping in accordance with NFPA 13.

F. Operation and Maintenance Manuals: Section 01 78 23, Operation and Maintenance Data. In addition to these requirements include data for fire suppression valves and automatic air vents.

G. Welding Certificates.

H. Welding report interpreting weld radiographs to the Resident Engineer without recommendations.

1.04 QUALITY ASSURANCE

A. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

B. Employ shop and field welders and/or welding operators and welding procedures qualified in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

C. Employ a licensed fire protection installer to install standpipe system.

D. Verify materials are clearly marked with the manufacturer's name, nameplate data or stamp, rating, and ASTM conformance number, as applicable.
   1. Use only fire protection system components and equipment that is Underwriters Laboratories (UL) Listed and labeled and Factory Mutual (FM) approved for use in fire protection systems. All piping materials shall as a minimum conform to the requirements of NFPA 13.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Pipe and Fittings
   1. Conform to NFPA 14, NFPA 130 and amendments to these codes adopted by the Seattle Fire Department. Secure grooved end product from a manufacturer with ISO 9001 certification.
   2. Pipe 2 Inches and Smaller: ASTM A53, Type S, Grade B or ASTM A106 seamless, Schedule 40, galvanized, threaded.
   3. Pipe 2-1/2 Inches and Larger: ASTM A53, Type S Grade B, plain-end or grooved end, schedule 40, galvanized. For grooved end, use only factory- or field-formed square cut or rolled-formed grooves per coupling manufacturers specifications. Pipe joints where cut grooves are required are identified on the drawings.
   4. Fittings 2 Inches and Smaller: Class 150 malleable iron threaded fittings conforming to ANSI B16.3. Conform to dimensions of ANSI B16.5.
5. Fittings 2-1/2 Inches and Larger: Ductile iron grooved end fittings conforming to ASTM A536 and as manufactured by the grooved end coupling manufacturer.

6. Grooved Joint Piping System: Mechanical grooved couplings for Pipe 2-1/2 Inches and Larger with grooved ends shall be flexible Victaulic Style 77 or rigid Style 07 type, hot dip galvanized from the factory and with Grade E, Ethylene Propylene Diene Monomer (EPDM) (negative 30 degrees F to 230 degrees F) standard style gaskets. Furnish coupling housings of ductile iron conforming to ASTM A536. For couplings from 2-inch through 6-inch size use couplings rated for a working pressure of at least 700 pounds per square inch (psi) and FM rated for 500 psi. Coupling Bolts and nuts: heat treated, zinc electroplated to ASTM B633 track-head style conforming to physical properties of ASTM A183 minimum tensile strength of 110,000 psi. Furnish all couplings and fittings from the same manufacturer.

7. Flanges for 2-1/2 pipe and larger: Class 150 forged steel, ASTM A105, weld neck, raised face or faced to match mating equipment or valves. Furnish gaskets with ANSI B16.21, 1/16-inch thick synthetic finish with nitrate builder. Flange Bolts: ASTM A307 Grade B bolts with A563 Grade A heavy nuts.

8. For all pipe and fittings described herein use only hot dip galvanized in accordance with Section 05 05 13, Shop Applied Coating For Metal. Furnish all mechanical grooved fittings hot dip galvanized from the vendors shop.

B. Valves

1. General:
   a. Furnish and install valves shown on the Contract Drawings, specified or shown for the control and easy maintenance of piping and equipment. Provide valves having proper clearances; leak proof at the specified test pressure; maker's name or brand; the figure or list number; the guaranteed ANSI working pressure cast on the body and cast or stamped on the bonnet. Provide valves of a given type from one manufacturer except for special application.

   b. Provide gate valves suitable for repacking under pressure.

   c. Valves used for fire protection piping shall be listed for fire protection service.

2. Ball Valves: Provide ball valves for drain service size as indicated. Where low point drains are not indicated, provide a minimum 1 inch size drain and ball valve.


   b. Ball valve: UL Listed and FM approved and rated for 600 psi water-oil-gas (WOG)

3. Butterfly Valves: Designed for fire protection service with grooved ends, polyphenylene sulfide blend coated ductile iron body. Disc shall be ductile iron conforming to ASTM A536 with electroless nickel coating conforming to ASTM B-
Furnish with nitrile (Grade T) seat conforming to ASTM D2000. Use only valves UL Listed for minimum 365 psi service in fire protection systems. Furnish valve with gear operated actuator and handwheel. Actuator shall have bronze traveling nut on a steel lead screw contained in a ductile iron housing. Valve shall have a black alkyd enamel coating. Furnish complete with two single-pole double-throw (SPDT) supervisory switches factory wired to junction box.

4. Fire Department Outlet Fire Hose Valves (FHV): 2-1/2 inch angle type cast brass; with a rough chrome plated finish, and valve rated to 300 psi. Furnish with red handwheel, female National Pipe Taper (NPT) inlet and the Seattle Fire Department compatible male hose thread outlet.

   a. Verify that valve is UL Listed and FM approved and furnish complete with brass cap and chain. Use fire hose valves of Elkhart Brass Model No. U-25-25 or approved equal by Kidde Fire Fighting or the Waterous Company.

5. Fire Department Outlet Pressure Reducing Fire Hose Valves (PRFHV): 2-1/2 inch angle type valve for use on high pressure standpipes to control nozzle pressure; cast brass construction with a rough chrome plated finish, valve rated to 400 psi inlet pressure. Valve shall operate automatically depending on inlet pressure and flow. Furnish with red handwheel, female National Pipe Taper (NPT) inlet and the Seattle Fire Department compatible male hose thread outlet.

   a. Verify that valve is UL Listed and FM approved and furnish complete with brass cap and chain. Use fire hose valves of Elkhart Brass Model No. UR-25-2.5 or approved equal by Kidde Fire Fighting or the Waterous Company.

6. Valves shall be factory set in accordance with the schedule on the drawings and be capable of flowing 300 gpm at inlet pressures greater than 175 psig and less than 400 psig, with outlet residual pressures between 170 psig and 130 psig at the 300 gpm delivered flow.

C. Automatic Air Vents:
   1. Provided where automatic air vents of 1/2-inch size as indicated.
   2. Furnish Automatic Air Vents, Claval series 34 or approved equal by APCO or Crispin. For Installation on vertical 1/2-inch threaded outlet connections off the top of the selected high points of the wet standpipe main.
   3. Air vents used in fire protection piping shall be UL listed or FM approved for fire protection service and rated for 400 psi working pressure.

D. Escutcheons:
   1. Split-hinged, locking type escutcheon held in place by either internal tension spring or a set-screw. Provide polished chromium-plated pressed steel material. Provide escutcheon to encompass the sleeve or opening.

E. Joint Pipe Couplings
   1. Grooved Joint Pipe Couplings: All pipe couplings shall be flexible-type except where rigid-type are indicated on the Contract Drawings.

F. Hangers & Supports:
1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. B-Line Systems, Inc.
   b. Grinnell Corp.
   c. GS Metals Corp.
   d. National Pipe Hanger Corp.
   e. PHD Manufacturing, Inc.

2. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated galvanized metallic coatings (hot dipped galvanized type) for support systems used in the tunnel.

3. Channel Support Systems: Consist of factory-fabricated components for field assembly as follows:
   a. Channel support shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS, Grade 33 and shall be hot-dip galvanized after fabrication in accordance with ASTM A123.
   b. All surface mounted struts in the tunnel shall be hot-dipped galvanized steel.
   c. Unless otherwise indicated on the Contract Drawings, surface mounted struts shall be 1-5/8- inch by 1-5/8- inch.
   d. Channel hole pattern shall accommodate attachment spacing and sized indicated.

4. All nuts, bolts, screws, clamps, brackets and miscellaneous fasteners in the tunnel shall be stainless steel.

G. Seismic Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES an agency acceptable to authorities having jurisdiction.
   a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of hot-dipped galvanized slotted steel channels and accessories for attachment to braced component at one end and to building or tunnel structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

H. Attachments

1. Refer to 21 05 00, Common Work Results For Fire Suppression

I. Structural Steel
1. Refer to Section 05 50 00, Metal Fabrications, for structural steel.

**PART 3 - EXECUTION**

**3.01 STANDPIPE COMPONENT INSTALLATION**

A. Install the standpipe systems as indicated, in accordance with requirements of NFPA 14.

B. Install standpipe piping so that it can be thoroughly drained and, where practicable, arranged to drain at the main drain valves.

C. Valve accessibility for operation and servicing is required. Install valves as indicated and with no stems located below the horizontal position.

D. Provide escutcheon plates at finished surfaces where exposed piping passes through floors, walls, and ceilings. Fasten escutcheons to pipe or pipe coverings.

E. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

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

G. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and the authorities having jurisdiction.

H. Install listed fire-protection shutoff valves supervised-open, located to control or isolate sources of water supply as shown on the Contract Drawings. Install permanent identification signs indicating extent of system controlled by each valve.

**3.02 APPLICATIONS**

A. Grooved Joint Pipe Couplings: All pipe couplings shall be flexible-type except where rigid-type are indicated on the drawings.

**3.03 HANGER AND SUPPORT INSTALLATION:**

A. Pipe hanger and support installation shall conform to the following:

1. Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure or the tunnel structure.

2. Space supports as indicated in the drawings. Install additional supports at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms.

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

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

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

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

7. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," are not exceeded.

3.04 CONSTRUCTION

A. Welding

1. Shop fabricate all major piping assemblies.

2. Field welding, in general, is not permitted. In specific cases and only with the approval of the Resident Engineer may the Contractor be allowed to field weld. Submit request to field weld with sufficient proof that no other method is feasible.

3. All welds shall have 100 percent penetration and smooth lines of fusion on the exterior and interior. Do not exceed 1/16-inch weld reinforcement.

4. Examine welds in accordance with the requirements of ANSI/ASW D1.1, Section 6, Parts A and B, and ASTM E94 and ASTM E1032, as applicable. In addition, examine by radiography 100 percent of the welds that are embedded in concrete or buried and examine fully by random radiography a minimum of 10 percent of all remaining circumferential butt welds.

B. Repair of Galvanized Surfaces:

1. Clean welds, bolted connections, field cut grooved pipe, and abraded areas such as rolled grooves on galvanized pipe and apply galvanizing-repair paint in accordance with Section 05 05 13, Shop Applied Coating For Metal.

3.05 IDENTIFICATION

A. Comply with the requirements of Section 22 05 50, Mechanical Identification.

3.06 FIELD QUALITY CONTROL

A. Testing

1. Perform 100 percent visual inspection of all field welds.

2. Test installed systems and products hydrostatically, using testing instruments calibrated by an Independent Testing Laboratory in accordance with Section 01 45 00, Quality Assurance/Quality Control, and flush after removal of testing equipment in accordance with applicable requirements of NFPA 14. Repair leaks and retest repaired parts of the system. Repair damages resulting from the system's failure during the test at no additional cost to Sound Transit.

   a. Test standpipe hydrostatically for two hours at the top most outlet. The test pressures for the standpipe system are as follows:

      1) Standpipe from UWS to Cross Passage No. 23: 360 psi.
2) Standpipe from Cross Passage No. 23 to Cross Passage No. Brooklyn Station: 300 psi.

3) Standpipe from Brooklyn Station to Cross Passage No. 31: 300 psi.

4) Standpipe from Cross Passage No. 31 to Roosevelt Station: 300 psi

b. Contractor shall provide and dispose of the quantity of water necessary for testing. Refer to Section 01 57 24, Temporary Site Water Discharge, for testing water disposal requirements.

1) The contract may request permission from the Resident Engineer to allow water provided for hydrostatic testing to remain if performed subsequent to all required pipe flushing.

3. Conduct standpipe system flow test in accordance with NFPA 14 including but not limited to the following:

a. System demand testing shall be conducted by flowing water at a rate of 300 gallons per minute at each installed pressure reducing fire hose valve and at any additional fire hose outlets required by the Seattle Fire Department.

4. Furnish items used in testing

a. Calibrate pressure gages.

b. Use testing instruments calibrated by a qualified laboratory in accordance with Section 01 45 00, Quality Assurance/Quality Control.

5. Perform tests in the presence of the Resident Engineer and Seattle Fire Department. Give 48-hour notice prior to test and notify the Seattle Fire Department and Seattle Public Utilities. The Resident Engineer will review certificates and test reports, and will inspect the standpipe system to verify conformance with NFPA 14.

END OF SECTION
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1.01 SUMMARY

A. This Section includes specifications for clean-agent extinguishing systems and the following:
   1. Piping and piping specialties.
   2. Extinguishing-agent containers.
   3. Extinguishing agent.
   5. Control and alarm panels.
   6. Accessories.
   7. Connection devices for and wiring between system components.
   8. Connection devices for power and integration into building's fire alarm system.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 21 05 00, Common Work Results for Fire Suppression.
   2. Section 22 05 29, Hangers and Supports For Plumbing Piping And Equipment.
   3. Section 23 05 29, Hangers and Supports For HVAC Piping And Equipment.
   4. Section 28 31 00, Fire Detection and Alarm.

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. B16.5 Pipe Flanges and Flanged Fittings
      b. B16.11 Forged Fittings, Socket-Welding and Threaded
      c. B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
      d. B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
      e. B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings
f. B18.2.1 Square and Hex Bolts and Screws, Inch Series

g. B31.1 Power Piping

   b. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   c. ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
   d. ASTM A536 Standard Specification for Ductile Iron Castings
   e. ASTM A563 Standard Specification for Carbons and Alloy Steel Nuts
   f. ASTM B88 Standard Specification for Seamless Copper Water Tube

3. American Welding Society (AWA)
   a. AWS A5.8 Standard Specification for Filler Metal for Brazing and Braze Welding
   b. AWS D10.12 Guide for Welding Mild Steel Pipe

4. American Water Works Association (AWWA)
   a. AWWA C606 Grooved and Shouldered Joints

5. City of Seattle (COS):
   a. Seattle Fire Code (International Fire Code with Seattle Amendments)

6. National Fire Protection Association (NFPA)
   a. NFPA 13 Standard for Installation of Sprinkler Systems
   b. NFPA 70 National Electric Code
   c. NFPA 72 National Fire Alarm Code
   d. NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems

7. National Electrical Manufacturers Association (NEMA)
   a. NEMA 1CS6 Industrial Controls and Systems: Enclosures

8. Underwriters Laboratories Inc.
   a. UL 213 Standard for Safety Rubber Gasketed Fittings for Fire Protection Service
   b. UL 268 Standard for Safety Smoke Detectors for Fire Alarm Signaling Systems
1.03 DEFINITIONS


C. BMS: Building Management System

1.04 SYSTEM DESCRIPTION

A. Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity below the ceiling.

1.05 PERFORMANCE REQUIREMENTS

A. Design clean-agent extinguishing system and obtain approval from the Seattle Fire Department. Design system for Class A or C fires as appropriate for areas being protected and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.

B. Performance Requirements: Discharge FK-5-1-12 within 10 seconds and maintain 5.9 percent concentration by volume at 70 degrees F for 10-minute holding time in hazard areas.

1. FK-5-1-12 concentration in hazard areas greater than 10.0 percent immediately after discharge or less than 5.0 percent throughout holding time will not be accepted without written authorization from Sound Transit and the Seattle Fire Department.

2. System Capabilities: Minimum 620-psig calculated working pressure and 360-psig initial charging pressure.

C. Cross-Zoned Detection: Devices in two separate detection zones. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating single-detection device in other detection zone.

D. System Operating Sequence: As follows:

1. Actuating First Detector: Visual indication on annunciator panel, energize audible alarm and visual alarms (slow pulse), activate contact closure to FACO for the following: shut down of air-conditioning and ventilating systems serving protected area, closure of HVAC fire/smoke dampers serving the protected area, closure of doors in protected area.

2. Actuating Second Detector: Visual indication on annunciator panel, energize audible and visual alarms (fast pulse), activate EPO switch, start time delay for extinguishing-agent discharge for 30 seconds, and discharge extinguishing agent.

3. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.

E. Manual stations shall immediately discharge extinguishing agent when activated.

F. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.
G. EPO: Will terminate power to protected equipment immediately on actuation.

H. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure alarm to FACP

1.06 SEISMIC PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-suppression piping and containers shall be capable of withstanding the effects of earthquake motions determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

1.07 PROJECT COORDINATION

A. See Section 01 31 13, Project Coordination, and Section 21 05 00, Common Work Results for Fire Suppression, for requirements.

1.08 SUBMITTALS

A. Product Data: For the following:

1. Extinguishing-agent containers.
2. Extinguishing agent.
3. Discharge nozzles.
4. Control panels.
5. Detection devices.
7. Switches.
8. Alarm devices.
9. Pipe hangers and supports, including seismic restraints.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Include design calculations. Include the following for hazard-area enclosure, drawn to scale:

1. Plans, elevations, sections, details, and attachments to other work. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Design Calculations: For weight, volume, and concentration of extinguishing agent required for each hazard area. Discharge time developed by clean agent distribution system. Standby power battery capacity.
4. Reflected Ceiling Plans: Show ceiling penetrations, ceiling-mounted items, and the following:
   a. Extinguishing-agent containers, piping, discharge nozzles, detectors, and accessories.
b. Method of attaching hangers to building structure.

c. Other ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, and access panels.

5. Occupied Work Area Plans: Show the following:

a. Controls and alarms.

b. Extinguishing-agent containers, piping and discharge nozzles if mounted in space, detectors, and accessories.

c. Equipment and furnishings.

C. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by the Seattle Fire Department. Include design calculations.

D. Field quality-control test reports.

E. Maintenance Data: For components to include in maintenance manuals.

1.09 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice the State of Washington and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of clean-agent extinguishing systems that are similar to those indicated for this Project in material, design, and extent.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of clean-agent extinguishing systems and are based on the specific system indicated. Refer to Section 01 66 00, Product Storage and Handling Requirements.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to Seattle Fire Marshal, and marked for intended use.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles were titles below introduce lists, the following requirements apply to product selection:

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

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

2.02 PIPING MATERIALS

A. Refer to Part 3 piping applications Article retained for applications of pipe, tube, fitting, and joining materials.
B. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

2.03 PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106, Grade B; Schedule 40, or Schedule 80, seamless steel pipe.
   
   1. Threaded Fittings:
      
      
      b. Flanges and Flanged Fittings: ASME B16.5, Class 300, unless Class 600 is indicated.

   2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.

   3. Grooved-End Fittings: FMG approved and NRTL listed, ASTM A 47/A 47M malleable iron or ASTM A 536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

B. Plain-End, Hard Copper Tube: ASTM B 88, Type K, water tube, drawn temper.
   
   

C. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, unless thickness or specific material is indicated.

D. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing.

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

G. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for halon or clean-agent service, and matching steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.04 VALVES

A. General: Brass; suitable for intended operation.

B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.

C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.

D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.
2.05 EXTINGUISHING-AGENT CONTAINERS

A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.

1. Finish: Red, enamel or epoxy paint.
2. Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
3. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

2.06 FIRE-EXTINGUISHING CLEAN AGENT

A. Clean Agent: FK-5-1-12, heptafluoropropane.

1. Available Manufacturers:
   a. Cerberus Pyrotronics.
   b. Chemetron Fire Systems.
   c. Fike Corporation.
   d. Kidde-Fenwal, Inc.
   e. Modular Protection Corp.

2.07 DISCHARGE NOZZLES

A. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, discharge pattern, and capacity required for application.

2.08 CONTROL PANELS

A. Description: FMG approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.

1. Mounting: Surface.

D. Supervised Circuits: Separate circuits for each independent detection zone.

1. Detection circuits equal to the required number of detection zones, or addressable devices assigned to the required number of zones.
3. Alarm circuit.
5. Abort circuit.
6. EPO circuit. Provide circuit with protected lugs for future connection by Owner.

E. Provide the following control-panel features:
1. Electrical contacts to FACP for shutting down fans, activating dampers, and operating system electrical devices.
2. Storage container, low-pressure indicator.
3. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

F. Annunciator Panel: Graphic type showing protected, hazard-area plans and locations of detectors, abort, EPO, and manual stations. Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless-steel or aluminum enclosure.

G. Standby Power: Lead-acid or nickel-cadmium batteries with capacity to operate system for 72 hours and alarm for minimum of 15 minutes. Include automatic battery charger, with varying charging rate between trickle and high depending on battery voltage that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, and suitable enclosure.

2.09 DETECTION DEVICES

A. Description: Comply with NFPA 2001 and NFPA 72, and include the following types:

1. Ionization Detectors: Comply with UL 268, dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.

2. Photoelectric Detectors: Comply with UL 268, consisting of LED light source and silicon photodiode receiving element.
   a. Pipe Network: CPVC tubing connects control unit with calibrated sampling holes.
   b. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of four preset values.
   c. Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg at all sampling ports.
   d. Control Unit: Single-zone unit as indicated on Drawings. Provides same system power supply, supervision, and alarm features as specified for the control panel plus separate trouble indication for airflow and detector problems.
   e. Signals to the Central Fire Alarm Control Panel: Any type of local system trouble is reported to the central fire alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to the central fire alarm control panel as separately identified zones.
2.10 MANUAL STATIONS

A. General Description: Surface FMG approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

D. EPO Switch: "EPO" caption, with yellow finish.

2.11 SWITCHES

A. Description: FMG approved or NRTL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

   1. Low-Agent Pressure Switches: Pneumatic operation.

   2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.

   3. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.12 ALARM DEVICES

A. Description: FMG approved or NRTL listed, low voltage, and surface mounting, unless otherwise indicated.

B. Bells: Minimum 6-inch diameter.

C. Horns: 90 to 94 dBA.

D. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

2.13 ELECTRICAL POWER AND WIRING

A. Electrical power, wiring, and devices are specified in Division 26.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with hazard-area leakage requirements, installation tolerances, and other conditions affecting work performance.

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

3.02 PIPING APPLICATIONS

A. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
B. Fittings Working Pressure: 620 psig minimum.
C. Flanged Joints: Class 300 minimum.
D. NPS 2 and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.
E. NPS 2-1/2 and NPS 3: Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.
F. NPS 4 and Larger: Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.

3.03 CLEAN-AGENT EXTINGUISHING PIPING INSTALLATION

A. Install clean-agent extinguishing piping and other components level and plumb and according to manufacturers' written instructions.
B. Refer to Section 21 05 00, Common Work Results for Fire Suppression, for basic pipe installation and joint construction.
C. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.
D. Install extinguishing-agent containers anchored to substrate.
E. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution," and in ASME B31.1.
   1. Install valves designed to prevent entrapment of liquid or install pressure relief devices in valved sections of piping systems.
   2. Support piping using supports and methods according to NFPA 13 and Section 22 05 29, Hangers and Supports for Plumbing Piping And Equipment, and Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.
   3. Install seismic restraints for extinguishing-agent containers and piping systems.
   4. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

3.04 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to extinguishing-agent containers to allow service and maintenance.
C. Connect electrical devices to control panel and to building's fire alarm system. Electrical power, wiring, and devices are specified in Section 28 31 00, Fire Detection and Alarm.

3.05 LABELING

A. Install labeling on piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.
B. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire extinguishing system.

C. Install signs at entry doors to advise persons outside the room the meaning of the bell(s), and strobe light(s) outside the protected space.

3.06 FIELD QUALITY CONTROL

A. Comply with operating instructions and procedures of NFPA 2001, Section "Approval of Installations." Include the following tests and inspections to demonstrate compliance with requirements:

1. Check mechanical items.

2. Inspect extinguishing-agent containers and extinguishing agent, and check mountings for adequate anchoring to substrate.

3. Check electrical systems.

   
   a. Room pressurization test shall be conducted in each protected space to determine the presence of openings, which would affect the agent concentration levels. The test(s) shall be conducted using the Retro-Tec Corp. Door Fan system, or equivalent, with integrated computer program. All testing shall be in accordance with NFPA 2001.
   
   b. If room pressurization testing indicates that openings exist which would result in leaks and/or loss of the extinguishing agent, the installing contractor shall be responsible for coordinating the proper sealing of the protected space(s) by the general contractor or his sub-contractor or agent. The general contractor shall be responsible for adequately sealing all protected space(s) against agent loss of leakage. The installing contractor shall inspect all work to ascertain that the protected space(s) have been adequately and properly sealed. THE SUPPRESSION SYSTEM INSTALLING CONTRACTOR SHALL BE RESPONSIBLE FOR THE SUCCESS OF THE ROOM PRESSURIZATION TESTS. If the first room pressurization test is not successful, in accordance with these specifications, the installing contractor shall direct the general contractor to determine, and correct, the cause of the test failure. The installing contractor shall conduct additional room pressurization tests, at no additional cost to the Owner, until a successful test is obtained. Copies of successful test results shall be submitted to the Owner for his record. Upon acceptance by the Owner, the completed system(s) shall be placed into service.

5. Perform functional pre-discharge test.


7. Check remote monitoring operations.

8. Check control-panel primary power source.

B. Perform field-acceptance tests of each clean-agent extinguishing system when installation is complete. The tests shall demonstrate that the entire control system
functions as designed and intended. All circuits shall be tested: automatic actuation and
manual actuation, HVAC and power shutdowns, audible and visual alarm devices, and
manual override of abort functions. Supervision of all panel circuits, including AC power
and battery power supplies, shall be tested and qualified. Perform system testing only
after hazard-area enclosure construction has been completed and openings sealed.
Comply with operating instructions and procedures of NFPA 2001, Section "Approval of
Installations." Include the following to demonstrate compliance with requirements:

1. Perform functional pre-discharge test.
2. Perform system functional operational test.
3. Check remote monitoring operations.
4. Check control-panel primary power source.
5. Perform "puff" test on piping system, using nitrogen.

C. Correct malfunctioning equipment, then retest to demonstrate compliance. Replace
equipment that cannot be corrected or does not perform as specified and indicated, then
retest to demonstrate compliance. Repeat procedure until satisfactory results are
obtained.

1. Report test results promptly and in writing to Resident Engineer and Seattle Fire
Department and the Seattle Building authorities having jurisdiction.

D. Perform the following field tests and inspections and prepare test reports:

1. After installing clean-agent extinguishing piping system and after electrical
circuitry has been energized, test for compliance with requirements.
2. Perform each electrical test and visual and mechanical inspection stated in
NETA ATS, Sections "Inspection and Test Procedures" and "System Function
Tests." Certify compliance with test parameters.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and
retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to
confirm proper motor rotation and unit operation. Remove malfunctioning units,
replace with new units, and retest.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning
controls and equipment.

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

3.07 CLEANING

A. Each pipe section shall be cleaned internally after preparation and before assembly by
means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free
of particulate matter and oil residue before installing nozzles or discharge devices.

3.08 SYSTEM FILLING

A. Preparation:

1. Verify that piping system installation is completed and cleaned.
2. Check for complete enclosure integrity.
3. Check operation of ventilation and exhaust systems.

B. Filling Procedures:
1. Fill extinguishing-agent containers with extinguishing agent and pressurize to indicated charging pressure.
2. Install filled extinguishing-agent containers.
3. Energize circuits.
4. Adjust operating controls.

3.09 COMMISSIONING
A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Clean Agent Fire Extinguisher System and equipment. Refer to Section 21 08 00 Commissioning of Fire Protection.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for materials and installation common to most piping systems including dielectric fittings, mechanical sleeve seals, sleeves, escutcheons, grout, equipment, concrete bases, and supports and anchorages.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 03 05 15, Portland Cement Concrete
2. Section 05 50 00, Metal Fabrications
3. Section 07 84 00, Firestopping

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society of Mechanical Engineers (ASME)
   a. ASME B1.20.1 Pipe Threads, General Purpose (Inch)

   a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   b. ASTM B32 Standard Specification for Solder Metal
   c. ASTM B813 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
   d. ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
   e. ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
   f. ASTM D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
   h. ASTM D2261 Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)
j. ASTM D2657 Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
k. ASTM D2672 Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
m. ASTM D2855 Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
n. ASTM D3138 Standard Specification for Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components
o. ASTM D3139 Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

3. American Welding Society (AWS)
   a. AWS A5.8 Specification for Filler Metals for Brazing and Braze Welding
   b. AWS D1.1 Errata for Structural Welding Code – Steel
   c. AWS D10.12 Guide for Welding Mild Steel Pipe

1.03 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, crawlspace, 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.
1.04 SUBMITTALS
   A. Procedures: Section 01 33 00, Submittal Procedures.
   B. 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

2.01 MATERIALS
   A. Pipe, Tube and Fittings
      1. Refer to individual Division 22, Plumbing, piping Sections for pipe, tube, and fitting materials and joining methods.
      2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.
   B. Joining Materials
      1. Refer to individual Division 22, Plumbing, piping Sections for special joining materials not listed below.
      2. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      3. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
      5. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.
      6. Solvent Cements for Joining Plastic Piping:
         a. CPVC Piping: ASTM F 493.
         b. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   C. Dielectric Fittings
      1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
      2. Insulating Material: Suitable for system fluid, pressure, and temperature.
      3. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 degrees F.
      4. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
5. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degrees F.

6. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F.

D. Mechanical Sleeve Seals

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

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

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

4. 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.

E. Sleeves

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

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

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

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

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

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

F. Escutcheons

1. 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.

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

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


5. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

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

H. **Flexible Expansion Joint For Vent and Roof Drain Piping**

1. **Description:** 150 psi rated, flexible loop capable of 4-inches movement in three planes and consisting of two flexible sections of hose and stainless steel braid, two 90-degree bends and one 180-degree return bend with hanger support nut and drain/air release plug. Bends and end connections shall be consistent with piping system specified in Section 21 13 16, Sanitary Waste and Vent Piping and 22 14 13, Facility Storm Drainage Piping. Provide MetraFlex Metraloop or equal.

**PART 3 - EXECUTION**

3.01 **ERECTION**

A. **Metal Supports and Anchorages**

1. Refer to Section 05 50 00, Metal Fabrications, for structural steel.

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

3. **Field Welding:** Comply with AWS D1.1.

3.02 **INSTALLATION**

A. **Piping Systems**

1. Install piping according to the following requirements and Division 22, Plumbing, Sections specifying piping systems.

2. Contract Drawings, 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.

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

4. 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.

5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.

7. Install piping at indicated slopes and at minimum of 1/8" per foot.

8. Install piping free of sags and bends.

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

10. Install piping to allow application of insulation.

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

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

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

   a. Install steel pipe for sleeves smaller than 6 inches in diameter.
   b. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
   c. 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.

15. Underground, Exterior-Wall and Sump Pit 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.
   a. 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.

16. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 00, Firestopping, for materials.

17. Verify final equipment locations for roughing-in.

18. Refer to equipment specifications in other Sections herein for roughing-in requirements.

19. Install flexible expansion joints where indicated on drawings and where piping crosses building seismic joints. Install vertical support hanger within 4 pipe diameters on each side of the flexible joints and seismic joint. Brace each hanger longitudinally and transversely. Install vertical support at 180-degree return bend.
B. Equipment

1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
3. 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.
4. Install equipment to allow right of way for piping installed at required slope.
5. Install equipment complying with sections 22 05 29 and 22 05 48.

3.03 APPLICATION

A. Grouting

1. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout in accordance with manufactures recommendations.

3.04 CONSTRUCTION

A. Piping Joint

1. Join pipe and fittings according to the following requirements and Division 22. Plumbing, Sections specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

6. 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:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
   a. Damaged Threads: Do not use pipe sections that have cracked or open welds.

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

9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   a. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
   b. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   c. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   d. 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.
   e. PVC Nonpressure Piping: Join according to ASTM D 2855.
   f. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.


12. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   a. Plain-End Pipe and Fittings: Use butt fusion.
   b. Plain-End Pipe and Socket Fittings: Use socket fusion.

B. Piping connections
1. Make connections according to the following, unless otherwise indicated:

   a. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

   b. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

   c. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

   d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

C. Concrete Bases

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

      a. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

      b. 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.

      c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

      d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

      e. Install anchor bolts to elevations required for proper attachment to supported equipment.

      f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

      g. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 05 15, Portland Cement Concrete.

END OF SECTION
SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

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

1.02 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.01 SLEEVES

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

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

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

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

2.02 STACK-SLEEVE FITTINGS

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

2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

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

1. Underdeck Clamp: Clamping ring with setscrews.
2.03 SLEEVE-SEAL SYSTEMS
A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

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

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

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

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

1. Presealed Systems.

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

2.05 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

3.01 SLEEVE INSTALLATION

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

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

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

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00, Joint Sealants.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 00, Firestopping.

3.02 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00, Sheet Metal Flashing and Trim.
   3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

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

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 00, Firestopping.

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.04 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.

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

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.

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

4. Concrete Slabs above Grade:


b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves Stack-sleeve fittings.

5. Interior Partitions:


END OF SECTION
SECTION 22 05 18
ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

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

1.02 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS
A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
B. One-Piece, Deep- Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
E. Split-Plate, Stamped- Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.02 FLOOR PLATES
A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

c. Insulated Piping: One-piece, cast brass or split casting brass type with polished, chrome plated finish. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

2. Escutcheons for Existing Piping:

a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.

b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.

f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.

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

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

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

2. Existing Piping: Split-casting, floor-plate type.

3.02 FIELD QUALITY CONTROL

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

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for thermometers and gages.
B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
C. 1. Section 22 08 00, Commissioning of Plumbing

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. ASME B40.3 Bimetallic Actuated Thermometers
      b. ASME B40.100 Pressure Gauges and Gauge Attachments
   2. Manufacturers Standardization Society for the Valve and Fittings Industry

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data for each type of product indicated.

PART 2 - PRODUCTS

2.01 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS
A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Contract Drawings or comparable product by one of the following:
   1. Palmer - Wahl Instruments Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
B. Case: Brass, 7 inches long.
C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.02 BIMETALLIC-ACTUATED DIAL THERMOMETERS

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

2. Ernst Gage Co.
3. Eugene Ernst Products Co.
5. Miljoco Corp.
6. NANMAC Corporation.
7. Noshok, Inc.
8. Palmer - Wahl Instruments Inc.
9. REO TEMP Instrument Corporation.
10. Tel-Tru Manufacturing Company.
11. Ttrerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: Liquid-filled type, stainless steel with 5-inch diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.
G. Window: Glass.
H. Ring: Stainless steel.
I. Connector: Adjustable angle type.
J. Stem: Metal, for thermowell installation and of length to suit installation.
K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.03 THERMOWELLS
A. Manufacturers: Same as manufacturer of thermometer being used.
B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.04 PRESSURE GAGES
A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Contract Drawings or comparable product by one of the following:
   1. AMETEK, Inc.; U.S. Gauge Div.
   3. Ernst Gage Co.
   4. Eugene Ernst Products Co.
   5. KOBOLD Instruments, Inc.
   7. Miljoco Corp.
   8. Noshok, Inc.
   10. REO TEMP Instrument Corporation.
   11. Trerice, H. O. Co.
   12. Weiss Instruments, Inc.
   13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   14. WIKA Instrument Corporation.
   15. Winters Instruments.
B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
   1. Case: Liquid-filled type, drawn steel or cast aluminum, 6-inch diameter.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.

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


7. Window: Glass.


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

10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.

11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.

2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

PART 3 - EXECUTION

3.01 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the outlet of each domestic, hot-water storage tank.

B. Install liquid-filled-case-type, bimetallic-actuated dial thermometers at suction and discharge of each pump.

C. Installation of thermal paste in wells shall be as per manufactures recommendations.

D. Provide the following temperature ranges for thermometers:

1. Domestic Hot Water: 30 to 180 degrees F, with 2-degree scale divisions.

2. Domestic Cold Water: 0 to 100 degrees F, with 2-degree scale divisions.

3.02 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.03 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees where thermometers are indicated.
C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install needle-valve and snubber fitting in piping for each pressure gage.

E. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

F. Adjust faces of thermometers and gages to proper angle for best visibility.

3.04 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Meters and Gages for Plumbing Piping systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following general-duty valves:
   1. Copper-alloy ball valves.
   2. Ferrous-alloy butterfly valves.
   5. Spring-loaded, lift-disc check valves.
   7. Cast-iron gate valves.
   8. Bronze globe valves.
   9. Cast-iron globe valves.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Division 21, Fire Suppression; and fire-protection valves
   2. Division 22 11 19, Plumbing; specialty valves
   3. Section 22 05 00, Common Work Results for Plumbing

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
      b. ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings
      c. ASME B16.5 Pipe Flanges and Flanged Fittings NPS ½ through NPS 24 Metric/Inch
      d. ASME B16.10 Face to Face and End to End Dimensions of Valves
      e. ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500 and 2500
2. American Water Works Association (AWWA)
   a. AWWA C606 Standard for Grooved and Shouldered Joints

3. National Sanitation Foundation (NSF)
   a. NSF 61 Drinking Water System Components

4. Manufacturers Standardization Society for the Valve and Fittings Industry (MMS)
   a. MSS SP-45 Bypass and Drain Connections
   b. MSS SP-67 Butterfly Valves
   c. MSS SP-70 Gray Iron Gate Valves, Flanged and Threaded Ends
   d. MSS SP-71 Gray Iron Swing Valves, Flanged and Threaded Ends
   e. MSS SP-80 Bronze Gate, Globe, Angle and Check Valves
   f. MSS SP-110 Ball Valves, Threaded, Socket-Weld, Solder Joint, Grooved and Flared Ends

1.03 SUBMITTALS

   A. Procedures: Section 01 33 00, Submittal Procedures.

   B. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; furnished specialties; and accessories.

1.04 QUALITY ASSURANCE

   A. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

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

2.02 VALVES, GENERAL

   A. Refer to Part 3 "Valve Applications" Article for applications of valves.

   B. Bronze Valves: NPS 2 and Smaller: Threaded ends, unless otherwise indicated.
C. Ferrous Valves: NPS 2-1/2 and Larger: Flanged ends, unless otherwise indicated.

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

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:
   1. Handwheel: For valves other than quarter-turn types.
   2. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.

G. Extended Valve Stems: On insulated valves.


I. Valve Grooved Ends: AWWA C606.
   1. Threaded: With threads according to ASME B1.20.1.

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

2.03 COPPER-ALLOY BALL VALVES

A. Available Manufacturers:
   1. Two-Piece, Copper-Alloy Ball Valves:
      b. Crane Co.; Crane Valve Group; Stockham Div.
      c. Milwaukee Valve Company.
   2. Three-Piece, Copper-Alloy Ball Valves:
      b. Crane Co.; Crane Valve Group; Stockham Div.
      c. Milwaukee Valve Company.

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Brass or bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

D. Three-Piece, Copper-Alloy Ball Valves: Brass or bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
2.04 FERROUS-ALLOY BUTTERFLY VALVES

A. Available Manufacturers:

1. Flangeless, Ferrous-Alloy Butterfly Valves:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Stockham Div.
   c. Grinnell Corporation.
   d. Milwaukee Valve Company.
   e. Mueller Steam Specialty.
   f. NIBCO INC.
   g. Tyco International, Ltd.; Tyco Valves & Controls.
   h. Watts Industries, Inc.; Water Products Div.

2. Single-Flange, Ferrous-Alloy Butterfly Valves:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Stockham Div.
   c. Grinnell Corporation.
   d. Milwaukee Valve Company.
   e. Mueller Steam Specialty.
   f. NIBCO INC.
   g. Tyco International, Ltd.; Tyco Valves & Controls.
   h. Watts Industries, Inc.; Water Products Div.

B. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated.

C. Flangeless, 250-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Wafer type with one- or two-piece stem.

D. Flangeless, 300-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Wafer type with one- or two-piece stem.


2.05 BRONZE CHECK VALVES

A. Available Manufacturers:
1. Type 2, Bronze, Horizontal Lift Check Valves with Nonmetallic Disc:
   a. Cincinnati Valve Co.
   b. Crane Co.; Crane Valve Group; Stockham Div.
   c. Walworth Co.

2. Type 1, Bronze, Vertical Lift Check Valves with Metal Disc:
   a. Cincinnati Valve Co.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Red-White Valve Corp.

3. Type 2, Bronze, Vertical Lift Check Valves with Nonmetallic Disc:
   a. Grinnell Corporation.
   b. Kitz Corporation of America.
   c. Milwaukee Valve Company.

4. Type 3, Bronze, Swing Check Valves with Metal Disc:
   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. Milwaukee Valve Company.
   e. Watts Industries, Inc.; Water Products Div.

5. Type 4, Bronze, Swing Check Valves with Nonmetallic Disc:
   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. Milwaukee Valve Company.
   e. Watts Industries, Inc.; Water Products Div.

B. Bronze Check Valves, General: MSS SP-80.

C. Type 2, Class 150, Bronze, Horizontal Lift Check Valves: Bronze body with nonmetallic disc and bronze seat.

D. Type 3, Class 200, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

E. Type 4, Class 200, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.
2.06  GRAY-IRON SWING CHECK VALVES

A.  Available Manufacturers:

1.  Type I, Gray-Iron Swing Check Valves with Metal Seats:
   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.  Milwaukee Valve Company.
   e.  Watts Industries, Inc.; Water Products Div.

2.  Type II, Gray-Iron Swing Check Valves with Composition to Metal Seats:
   a.  Crane Co.; Crane Valve Group; Crane Valves.
   b.  Crane Co.; Crane Valve Group; Stockham Div.

3.  Grooved-End, Ductile-Iron Swing Check Valves:
   a.  Grinnell Corporation.
   b.  Mueller Co.
   c.  Victaulic Co. of America.


C.  Type I, Class 250, gray-iron, swing check valves with metal seats.

D.  Type II, Class 250, gray-iron, swing check valves with composition to metal seats.

E.  175-psig CWP Rating, Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends.

F.  300-psig CWP Rating, Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends.

2.07  SPRING-LOADED, LIFT-DISC CHECK VALVES

A.  Available Manufacturers:

1.  Type I, Wafer Lift-Disc Check Valves:
   a.  Mueller Steam Specialty.

2.  Type II, Compact-Wafer, Lift-Disc Check Valves:
   a.  GA Industries, Inc.
   b.  Grinnell Corporation.
   c.  Milwaukee Valve Company.
d. NIBCO INC.
e. Valve and Primer Corp.

3. Type III, Globe Lift-Disc Check Valves:
   a. Durabla Fluid Technology, Inc.
   b. Flomatic Valves.
   c. Grinnell Corporation.
   d. Metraflex Co.
   e. Milwaukee Valve Company.

4. Type IV, Threaded Lift-Disc Check Valves:
   a. Grinnell Corporation.
   b. Metraflex Co.
   c. Milwaukee Valve Company.

B. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.

C. Type I, Class 250, Wafer Lift-Disc Check Valves: Wafer style with cast-iron shell with diameter matching companion flanges.

D. Type II, Class 250, Compact-Wafer, Lift-Disc Check Valves: Compact-wafer style with cast-iron shell with diameter made to fit within bolt circle.

E. Type III, Class 250, Globe Lift-Disc Check Valves: Globe style with cast-iron shell and flanged ends.

F. Type IV, Class 150, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends.

2.08 BRONZE GATE VALVES

A. Available Manufacturers:

1. Type 1, Bronze, Nonrising-Stem Gate Valves:
   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. Milwaukee Valve Company.
   e. Watts Industries, Inc.; Water Products Div.

2. Type 2, Bronze, Rising-Stem, Solid-Wedge Gate Valves:
b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Milwaukee Valve Company.

B. Bronze Gate Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 1, Class 200, Bronze Gate Valves: Bronze body with nonrising stem and bronze solid wedge and union-ring bonnet.

D. Type 2, Class 200, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

2.09 CAST-IRON GATE VALVES

A. Available Manufacturers:

1. Type I, Cast-Iron, Nonrising-Stem Gate Valves:
   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. Milwaukee Valve Company.
   e. NIBCO INC.

2. Type I, Cast-Iron, Rising-Stem Gate Valves:
   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. Milwaukee Valve Company.
   e. Watts Industries, Inc.; Water Products Div.

B. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

C. Class 250, NRS, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, nonrising stem, and solid-wedge disc.

D. Class 250, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

E. Class 250, NRS, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, nonrising stem, and solid-wedge disc.

F. Class 250, OS&Y, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, rising stem, and solid-wedge disc.
2.10 BRONZE GLOBE VALVES

A. Available Manufacturers:
   
   1. Type 1, Bronze Globe Valves with Metal Disc:
      
      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. Milwaukee Valve Company.
   
   2. Type 2, Bronze Globe Valves with Nonmetallic Disc:
      
      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. Milwaukee Valve Company.

B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 2, Class 200, Bronze Globe Valves: Bronze body with PTFE or TFE disc and union-ring bonnet.

2.11 CAST-IRON GLOBE VALVES

A. Available Manufacturers:
   
   1. Type I, Cast-Iron Globe Valves with Metal Seats:
      
      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. Milwaukee Valve Company.

B. Type I, Class 250, Cast-Iron Globe Valves: Gray-iron body with bronze seats.

PART 3 - EXECUTION

3.01 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
   
   1. Shutoff Service: Ball, butterfly, gate, or plug valves.
   2. Throttling Service: Angle, ball, butterfly, or globe valves.
B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.

C. Domestic Water Piping: Use the following types of valves:
   1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
   2. Ball Valves, NPS 2-1/2 and Larger: Class 300, ferrous alloy.
   4. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 200, bronze.
   5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 250, gray iron.
   6. Wafer Check Valves, NPS 2-1/2 and Larger: Dual-plate, wafer double-flanged, Class 250 or 300, ferrous alloy.
   7. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 200.
   8. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type I or II, Class 250, cast iron.

D. Sanitary Waste and Storm Drainage Piping: Use the following types of valves:
   1. Ball Valves, NPS 2 and Smaller: Two-piece, 400-psig CWP rating, copper alloy.
   2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
   3. Swing Check Valves, NPS 2 and Smaller: Type 3, Class, bronze.
   4. Swing Check Valves, NPS 2-1/2 and Larger: Type I or II, Class 125, gray iron.
   5. Gate Valves, NPS 2 and Smaller: Type 1, Class 150, bronze.
   6. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS&Y, bronze-mounted cast iron.
   7. Globe Valves, NPS 2 and Smaller: Type 1, Class 150, bronze.
   8. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, cast iron.

E. Select valves, except wafer and flangeless types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: threaded ends.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.
3.02 VALVE INSTALLATION

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

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

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

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

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

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

3.03 JOINT CONSTRUCTION

A. Refer to Section 22 05 00, Common Work Results for Plumbing, for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.04 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.

3.05 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain General Duty Valves for Plumbing Piping systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the following items:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Equipment supports.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 05 50 00, Metal Fabrications; structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 21 10 00, Water-Based Fire-Suppression Systems; pipe hangers for fire-suppression piping.
   3. Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment; vibration isolation devices.

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American National Standards Institute (ANSI)
      a. B16.3 Malleable Iron Threaded Fittings
      b. B16.5 Pipe Flanges and Flanged Fittings
      c. B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
      d. B31.1 Power Piping
   2. American Society of Mechanical Engineers (ASME)
      a. Boiler and Pressure Vessel Code (BPVC), Section IX, Welding and Brazing Qualifications
   3. American Society for Testing and Materials International (ASTM)
a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

b. ASTM A105 Standard Specification for Carbon Steel Forgings for Piping Applications

c. ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

d. ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

e. ASTM A183 Standard Specification for Carbon Steel Track Bolts and Nuts

f. ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength

g. ASTM A536 Standard Specification for Ductile Iron Castings

h. ASTM A563 Standard Specification for Carbons and Alloy Steel Nuts

i. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

j. ASTM B16 Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines

k. ASTM B633 Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

4. Manufacturers Standardization Society for the Valve and Fittings Industry

a. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture

b. MSS SP-69 Pipe Hangers and Supports – Selection and Applications

c. MSS SP-89 Pipe Hangers and Supports – Fabrications and Installation Practices

d. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports

5. National Fire Protection Association (NFPA)

a. NFPA 13 Standard for Installation of Sprinkler Systems

b. NFPA 14 Installation of Standpipe and Hose Systems

c. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail

1.03 DEFINITIONS

A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."
1.04 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction and section 22 05 48

1.05 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Equipment supports.

D. Welding certificates. In accordance with welding specification.

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

1.06 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 Articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2.02 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Article 3.01 for locations to use specific hanger and support types.

B. Available Manufacturers:
   1. AAA Technology & Specialties Co., Inc.
   2. Bergen-Power Pipe Supports.
   4. Carpenter & Paterson, Inc.
   5. Empire Industries, Inc.
   6. ERICO/Michigan Hanger Co.
   7. Globe Pipe Hanger Products, Inc.
   8. Grinnell Corp.
   9. GS Metals Corp.
   11. PHD Manufacturing, Inc.
   12. PHS Industries, Inc.
   13. Piping Technology & Products, Inc.
   14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.03 TRAPEZE PIPE HANGERS

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

2.04 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:
   2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer’s standard finish, unless bare metal surfaces are indicated.
D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.05 THERMAL-HANGER SHIELD INSERTS
A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.
B. Available Manufacturers:
1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.
C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

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

1. Available Manufacturers:
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
2.07 EQUIPMENT SUPPORTS
A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.08 MISCELLANEOUS MATERIALS
A. Structural Steel: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
B. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS
A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
E. Use padded hangers for piping that is subject to scratching.
F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
   4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
   5. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.

7. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.

8. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with barjoist construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches

2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

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

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

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

3.02 HANGER AND SUPPORT INSTALLATION

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

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

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

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

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
E. Fastener System Installation:
   1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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


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

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

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

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood inserts.

6. Insert Material: Length at least as long as protective shield.

7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS

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

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

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

3.04 METAL FABRICATIONS

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

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

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

3.06 PAINTING

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

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 22 05 33
HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes heat tracing with the following electric heating cables:
   1. Self-regulating, parallel resistance.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 22 07 00, Plumbing Insulation.
   2. Section 26 05 26, Grounding and Bonding for Electrical Systems.
   3. Section 26 05 25, Wire and Cable.

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. National Electrical Manufacturers Association (NEMA)
      a. NEMA 3R Raintight, Sleet Resistant - Outdoor
   2. Institute of Electrical and Electronics Engineers (IEEE)

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
   1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

C. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
F. Warranty: Special warranty specified herein.

1.04 QUALITY ASSURANCE

A. Heat Trace Cables: UL Listed for use on Fire Protection System Piping.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to Seattle Electrical Inspector marked for intended use.

1.05 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Thermon FLX Self Regulating Heating Cable and Thermon GPT-3 Freeze Protection Thermostat or a comparable product by one of the following:

1. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
3. Raychem; a division of Tyco Thermal Controls.

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

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Tinned-copper braid, and polyolefin outer jacket with UV inhibitor.

E. Maximum Operating Temperature (Power On): 150 degrees F.

F. Maximum Exposure Temperature (Power Off): 185 degrees F.

G. Maximum Operating Temperature: 300 degrees F.

H. Capacities and Characteristics:

3. Number of Parallel Cables: 1
4. Volts: 277 V.
5. Phase: 1
6. Hertz: 60 Hz.
7. Maximum Circuit Length for 0 degrees F Start-up Temperature: 649 ft.

2.02 CONTROLS

A. Heater Trace Circuit Controller: Automatic electronic controller with input for remote temperature sensor input, internal ground fault protection, and monitoring functions for each heat trace circuit.
   1. Control Range: 41 deg F to 77 degrees F adjustable, with 2 degrees F dead band.
   2. Electrical Supply: 277 V, 1 phase, 60 hertz; 2-pole contact for 30 amps maximum load.
   3. GFI Protection: 30, 60, 90, or 120 mA selectable with automatic reset.
   4. Monitoring Functions: Power-on self-check, heater operation, GFI protection and ground leakage current tested every 24 hours, temperature sensor operation, and contactor operation.
   5. Alarm Relay: Single-throw double-pole 1 amp class 2 contact.
   6. Indicators: Lights mounted on enclosure for normal power, call for heat, ground fault occurrence, or a failure of the monitored functions.
   7. Enclosure: NEMA 3R.

B. Remote temperature sensor: Resistance Temperature Detector (RTD) for directly sensing pipe-wall temperature at beginning and end of each heat trace circuit.

2.03 ACCESSORIES

A. Cable Installation Accessories: Pipe-mounted non-metallic heat trace power circuit connection box, Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

2.04 RTD EXTENSION WIRE

A. For extending RTD signal leads; Silver-plated copper wire with Teflon or PVC insulation and jacket; 2 or 3 conductors as required by Heat Trace Circuit Controller manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 22 07 00, Plumbing Insulation.

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

F. Protect installed heating cables, including non-heating leads, from damage.

3.03 CONNECTIONS

A. Ground equipment according to Section 26 05 26, Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 05 25, Wire and Cable.

3.04 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

1. Test cables for electrical continuity and insulation integrity before energizing.

2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

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

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

3.05 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Heat Tracing for Plumbing Piping systems and equipment See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
SECTION 22 05 48
VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Restraining braces and cables.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment
2. Section 22 11 16, Domestic Water Piping

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society for Testing and Materials International (ASTM)
   a. ASTM A53 Standard Specification for Stainless Steel Rope Wire
2. American Welding Society (AWS)
   a. AWS D1.1/D1.1M Structural Welding Code – Steel, Second Printing, Errata
3. City of Seattle (COS):
4. Manufacturers Standardization Society for the Valve and Fittings Industry
   a. MSS SP-127 Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application

1.03 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: C.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
      a. Component Importance Factor: 1.5.
      b. Component Response Modification Factor: 2.5.
      c. Component Amplification Factor: 2.5.
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 10.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each product indicated.
C. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
D. Welding certificates.
E. Qualification Data: For professional engineer.
F. Field quality-control test reports.

1.05 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
C. Seismic-restraint devices and design shall have horizontal and vertical load testing and analysis and shall bear anchorage pre approved by ICC-ES, or pre-approved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
PART 2 - PRODUCTS

2.01 VIBRATION ISOLATORS

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

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

C. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant rubber.

D. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
F. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

G. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

H. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.

2. Base: Factory drilled for bolting to structure.

3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

I. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

J. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. **Frame:** Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. **Outside Spring Diameter:** Not less than 80 percent of the compressed height of the spring at rated load.

3. **Minimum Additional Travel:** 50 percent of the required deflection at rated load.

4. **Lateral Stiffness:** More than 80 percent of rated vertical stiffness.

5. **Overload Capacity:** Support 200 percent of rated load, fully compressed, without deformation or failure.

6. **Elastomeric Element:** Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. **Self-centering hanger rod cap** to ensure concentricity between hanger rod and support spring coil.

**K. Spring Hangers with Vertical-Limit Stop:** Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. **Frame:** Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. **Outside Spring Diameter:** Not less than 80 percent of the compressed height of the spring at rated load.

3. **Minimum Additional Travel:** 50 percent of the required deflection at rated load.

4. **Lateral Stiffness:** More than 80 percent of rated vertical stiffness.

5. **Overload Capacity:** Support 200 percent of rated load, fully compressed, without deformation or failure.

6. **Elastomeric Element:** Molded, oil-resistant rubber or neoprene.

7. **Adjustable Vertical Stop:** Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. **Self-centering hanger rod cap** to ensure concentricity between hanger rod and support spring coil.

**L. Pipe Riser Resilient Support:** All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

**M. Resilient Pipe Guides:** Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.
2.02 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work.

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product required for the equipment indicated on Contract Drawings or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.

C. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

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

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

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

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

I. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
PART 3 - EXECUTION

3.01 APPLICATIONS

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

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

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

3.02 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

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

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

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

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

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

G. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.03 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION
A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 11 16, Domestic Water Piping for piping flexible connections.

3.04 FIELD QUALITY CONTROL
A. Perform tests and inspections.
B. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to Resident engineer and the City of Seattle Code Authorities.
   2. Schedule test with Resident Engineer, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least 7 days' advance notice.
   3. Obtain Resident Engineer's approval before transmitting test loads to structure. Provide temporary load-spreading members.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Resident Engineer.
   5. Test to 90 percent of rated proof load of device.
   7. Measure isolator deflection.
   8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
C. Remove and replace malfunctioning units and retest as specified above.
D. Prepare test and inspection reports.

3.05 ADJUSTING
A. Adjust isolators after piping system is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.06 PLUMBING VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. As Indicated on Contract Drawings

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 09 96 00, High-Performance Coatings.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. ASME A13.1 Scheme for Identification of Piping Systems

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS
A. Metal Labels for Equipment:
   1. Material and Thickness: Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 by 11-inch bond paper. Tabulate equipment identification number and identify Contract Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Contract Specifications Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS FOR BACK OF HOUSE

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


C. Background Color: Black.

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

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

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

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

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

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

2.03 PIPE LABELS

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

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

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

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Contract Drawings, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches high.

**PART 3 - EXECUTION**

3.01 PREPARATION

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

3.02 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

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

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.


B. Pipe Label Color Schedule:

1. Domestic Water Piping:
   a. Background Color: Blue.

2. Sanitary Waste Piping:
3. Storm Drainage Piping:
   a. Background Color: Black.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 22 07 00
PLUMBING INSULATION

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for:
   1. Insulation Materials:
      a. Mineral fiber.
   2. Insulating cements.
   3. Adhesives.
   5. Sealants.
   6. Factory-applied jackets.
   8. Field-applied jackets.
  10. Securements.
  11. Corner angles.
B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 07 84 00, Firestopping
   2. Section 09 90 00, Painting and Coating
   3. Section 23 07 00 HVAC Insulation

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society for Testing and Materials International (ASTM)
      a. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each type of product indicated.

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

D. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by an Independent Testing Laboratory acceptable to Resident Engineer and the City of Seattle Code authority. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable Independent Testing Laboratory.

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

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

PART 2 - PRODUCTS

2.01 MATERIALS

A. Insulation Materials
   1. Comply with requirements in Article 3.04 for where insulating materials shall be applied.

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

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

   4. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.
a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Johns Manville; HTB 23 Spin-Glas.
2) Owens Corning; High Temperature Flexible Batt Insulations.

5. For operating temperatures higher than 250 degrees F, use high-temperature board insulation in first paragraph below.


a. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. See Section 01 66 00, Product Storage and Handling Requirements.

b. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Fibrex Insulations Inc.; FBX.
2) Johns Manville; 1000 Series Spin-Glas.
3) Owens Corning; High Temperature Industrial Board Insulations.
4) Rock Wool Manufacturing Company; Delta Board.
5) Roxul Inc.; Roxul RW.
6) Thermafiber; Thermafiber Industrial Felt.

7. Mineral-Fiber, Preformed Pipe Insulation:

a. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. See Section 01 66 00, Product Storage and Handling Requirements.

b. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Fibrex Insulations Inc.; Coreplus 1200.
2) Johns Manville; Micro-Lok.
3) Knauf Insulation; 1000 Pipe Insulation.
4) Manson Insulation Inc.; Alley-K.
5) Owens Corning; Fiberglas Pipe Insulation.
8. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 degrees F is 0.29 Btu x in./h x sq. ft. x degrees F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets” Article.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) CertainTeed Corp.; CrimpWrap.
      2) Johns Manville; MicroFlex.
      3) Knauf Insulation; Pipe and Tank Insulation.
      4) Manson Insulation Inc.; AK Flex.
      5) Owens Corning; Fiberglas Pipe and Tank Insulation.

B. Insulating Cements


   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) Insulco, Division of MFS, Inc.; SmoothKote.
      3) Rock Wool Manufacturing Company; Delta One Shot.

C. Adhesives

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

2. Cellular-Glass Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) Childers Products, Division of ITW; CP-96.
      2) Foster Products Corporation, H. B. Fuller Company; 81-33.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Childers Products, Division of ITW; CP-82.
2) Foster Products Corporation, H. B. Fuller Company; 85-20.
3) ITW TACC, Division of Illinois Tool Works; S-90/80.
4) Marathon Industries, Inc.; 225.
5) Mon-Eco Industries, Inc.; 22-25.

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

5. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Childers Products, Division of ITW; CP-35.
2) Foster Products Corporation, H. B. Fuller Company; 30-90.
3) ITW TACC, Division of Illinois Tool Works; CB-50.
4) Marathon Industries, Inc.; 590.
5) Mon-Eco Industries, Inc.; 55-40.
6) Vimasco Corporation; 749.

b. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.

c. Service Temperature Range: Minus 20 to plus 180 degrees F.

d. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.

e. Color: White.

6. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Childers Products, Division of ITW; CP-10.
2) Foster Products Corporation, H. B. Fuller Company; 35-00.
3) ITW TACC, Division of Illinois Tool Works; CB-05/15.
6) Vimasco Corporation; WC-1/WC-5.

b. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
c. Service Temperature Range: Minus 20 to plus 200 degrees F.
d. Solids Content: 63 percent by volume and 73 percent by weight.
e. Color: White.

D. Sealants

1. Joint Sealants:
   a. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Childers Products, Division of ITW; CP-76.
      2) Foster Products Corporation, H. B. Fuller Company; 30-45.
      3) Marathon Industries, Inc.; 405.
      4) Mon-Eco Industries, Inc.; 44-05.
      5) Pittsburgh Corning Corporation; Pittseal 444.
      6) Vimasco Corporation; 750.
   b. Materials shall be compatible with insulation materials, jackets, and substrates.
   c. Permanently flexible, elastomeric sealant.
   d. Service Temperature Range: Minus 100 to plus 300 degrees F.
   e. Color: White or gray.

2. FSK and Metal Jacket Flashing Sealants:
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Childers Products, Division of ITW; CP-76-8.
      2) Foster Products Corporation, H. B. Fuller Company; 95-44.
      3) Marathon Industries, Inc.; 405.
      4) Mon-Eco Industries, Inc.; 44-05.
      5) Vimasco Corporation; 750.
b. Materials shall be compatible with insulation materials, jackets, and substrates.

c. Fire- and water-resistant, flexible, elastomeric sealant.

d. Service Temperature Range: Minus 40 to plus 250 degrees F.

e. Color: Aluminum.

E. Factory-Applied Jackets

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

   a. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

F. Field-Applied Jackets

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


   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) Childers Products, Division of ITW; Metal Jacketing Systems.
      2) PABCO Metals Corporation; Surefit.
      3) RPR Products, Inc.; Insul-Mate.

   b. Sheet and roll stock ready for shop or field sizing.

   c. Finish and thickness are indicated in field-applied jacket schedules.

   d. Moisture Barrier for Indoor Applications: 2.5-mil-thick Polysurlyn.

   e. Moisture Barrier for Outdoor Applications: 2.5-mil-thick Polysurlyn.

   f. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Pittsburgh Corning Corporation; Pittwrap.
      2) Polyguard; Insulrap No Torch 125.

G. Tapes

1. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      2) Compac Corp.; 110 and 111.
      3) Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
      4) Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
   b. Width: 3 inches.
   c. Thickness: 6.5 mils.
   d. Adhesion: 90 ounces force/inch in width.
   e. Elongation: 2 percent.
   f. Tensile Strength: 40 lbf/inch in width.
   g. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
      2) Compac Corp.; 120.
3) Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
4) Venture Tape; 3520 CW.

b. Width: 2 inches.

c. Thickness: 3.7 mils.

d. Adhesion: 100 ounces force/inch in width.

e. Elongation: 5 percent.

f. Tensile Strength: 34 lbf/inch in width.

H. Securements

1. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) Childers Products; Bands.
      2) PABCO Metals Corporation; Bands.
      3) RPR Products, Inc.; Bands.

2. Insulation Pins and Hangers:

   a. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

      1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

         a) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
         b) GEMCO; Perforated Base.
         c) Midwest Fasteners, Inc.; Spindle.

            i) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

            ii) Spindle: Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

            iii) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
b. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) GEMCO; Nylon Hangers.

b) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

i) Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

ii) Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.

iii) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

c. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.

b) GEMCO; Press and Peel.

c) Midwest Fasteners, Inc.; Self Stick.

2) Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

3) Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

4) Adhesive-backed base with a peel-off protective cover.

d. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a) AGM Industries, Inc.; RC-150.
b) GEMCO; R-150.
c) Midwest Fasteners, Inc.; WA-150.
d) Nelson Stud Welding; Speed Clips.

2) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

e. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) GEMCO.
b) Midwest Fasteners, Inc.


I. Corner Angles

1. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.01 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.02 INSTALLATION

A. General Installation Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

4. Install insulation with longitudinal seams at top and bottom of horizontal runs.

5. Install multiple layers of insulation with longitudinal and end seams staggered.

6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.


8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

9. Install insulation with least number of joints practical.

10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
    a. Install insulation continuously through hangers and around anchor attachments.
    b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
    c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
    d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

12. Install insulation with factory-applied jackets as follows:
    a. Draw jacket tight and smooth.
    b. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
    c. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
       1) For below ambient services, apply vapor-barrier mastic over staples.
d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.

e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

16. For above ambient services, do not install insulation to the following:

a. Vibration-control devices.
b. Independent Testing Laboratory labels and stamps.
c. Nameplates and data plates.
d. Manholes.
e. Handholes.
f. Cleanouts.

B. Penetrations

1. Insulation Installation at Roof Pen penetrations: Install insulation continuously through roof penetrations.

a. Seal penetrations with flashing sealant.
b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

d. Seal jacket to roof flashing with flashing sealant.

2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

a. Seal penetrations with flashing sealant.
b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

d. Seal jacket to wall flashing with flashing sealant.

4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   a. Comply with requirements in Section 07 84 00, Firestopping.

6. Insulation Installation at Floor Penetrations:
   a. Pipe: Install insulation continuously through floor penetrations.
   b. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 00, Firestopping.

C. Equipment, Tank, and Vessel Insulation Installation

1. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
   b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   c. Protect exposed corners with secured corner angles.
   d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      1) Do not weld anchor pins to ASME-labeled pressure vessels.
      2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      3) On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches on center in both directions.
      4) Do not overcompress insulation during installation.
      5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
      6) Impale insulation over anchor pins and attach speed washers.
      7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

g. Stagger joints between insulation layers at least 3 inches.

h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

   a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.

   b. Seal longitudinal seams and end joints.

D. General Pipe Insulation Installation

   1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

   2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

      a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

      b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

4. Install removable insulation covers at locations indicated. Installation shall conform to the following:

a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
b. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or unions long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

E. Cellular-Glass Insulation Installation

1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
   d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

3. Insulation Installation on Pipe Fittings and Elbows:
a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of cellular-glass insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

F. Mineral-Fiber Insulation Installation
   1. Insulation Installation on Straight Pipes and Tubes:
      a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
      b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
      c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
      d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
   2. Insulation Installation on Pipe Flanges:
      a. Install preformed pipe insulation to outer diameter of pipe flange.
      b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
      c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
      d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
   3. Insulation Installation on Pipe Fittings and Elbows:
      a. Install preformed sections of same material as straight segments of pipe insulation when available.
      b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   d. Install insulation to flanges as specified for flange insulation application.

G. Polyolefin Insulation Installation

1. Insulation Installation on Straight Pipes and Tubes:
   a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

2. Insulation Installation on Pipe Flanges:
   a. Install pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
   d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install mitered sections of polyolefin pipe insulation.
   b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

4. Insulation Installation on Valves and Pipe Specialties:
   a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.
   d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

5. Insulation Installation on Pipe Flanges:
a. Install preformed pipe insulation to outer diameter of pipe flange.

b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

6. Insulation Installation on Pipe Fittings and Elbows:

a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer’s written instructions.

7. Insulation Installation on Valves and Pipe Specialties:

a. Install preformed section of polystyrene insulation to valve body.

b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

c. Install insulation to flanges as specified for flange insulation application.

H. Field-Applied Jacket Installation

1. Where FSK jackets are indicated, install as follows:

a. Draw jacket material smooth and tight.

b. Install lap or joint strips with same material as jacket.

c. Secure jacket to insulation with manufacturer’s recommended adhesive.

d. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.

e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

2. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches on center and at end joints.

I. Underground, Field-Installed Insulation Jacket

1. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
1. Inspect field-insulated equipment, randomly selected by Resident Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

2. Inspect pipe, fittings, strainers, and valves, randomly selected by Resident Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.04 SCHEDULES

A. Equipment Insulation Schedule

1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

2. Insulate indoor and outdoor equipment in Articles below that is not factory insulated.

3. Domestic water, domestic chilled-water (potable), and domestic hot-water hydropneumatic tank insulation shall be the following:


B. Piping Insulation Schedule, General

1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor’s option.

2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

   a. Drainage piping located in crawl spaces.

   b. Underground piping.

   c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
C. Indoor Piping Insulation Schedule

1. Domestic Hot and Recirculated Hot Water: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. Domestic Chilled Water (Potable): Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3. Stormwater and Overflow: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

4. Roof Drain and Overflow Drain Bodies: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

5. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

6. Sanitary Waste Piping Where Heat Tracing Is Installed: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.

D. Outdoor, Aboveground Piping Insulation Schedule

1. Domestic Water Piping: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

2. Sanitary Waste Piping Where Heat Tracing Is Installed: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

E. Outdoor, Underground Piping Insulation Schedule


F. Indoor, Field-applied Jacket Schedule

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

2. If more than one material is listed, selection from materials listed is Contractor's option.

3. Equipment, Concealed:
   a. None.

4. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
a. Aluminum, Smooth: 0.020 inch thick.

5. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

6. Piping, Concealed:
   a. None.

7. Piping, Exposed:
   a. Aluminum, Smooth: 0.020 inch thick.

G. Outdoor, Field-applied Jacket Schedule

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

2. If more than one material is listed, selection from materials listed is Contractor’s option.

3. Equipment, Concealed:
   a. Aluminum, Smooth: 0.020 inch thick.

4. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   a. Aluminum, Smooth with Z-Shaped Locking Seam: 0.024 inch thick.

5. Piping, Concealed:
   a. None.

6. Piping, Exposed:
   a. Aluminum, Smooth: 0.024 inch thick.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Commissioning process requirements for Plumbing:

1. Level 1 commissioning activities for plumbing.
2. Level 2 commissioning activities for plumbing.
3. Support for Level 3 commissioning activities related to plumbing.
4. Support for Level 4 commissioning activities related to plumbing.

B. Related Sections:

1. Section 01 91 13, General Commissioning Requirements for: General commissioning process requirements, including definitions, submittals, scheduling, execution of commissioning activities, and reporting.
2. Section 22 05 19, Meters and Gages for Plumbing Piping
3. Section 22 05 23, General-Duty Valves for Plumbing Piping
4. Section 22 05 33, Heat Tracing For Plumbing Piping
5. Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment
6. Section 22 11 16, Domestic Water Piping
7. Section 22 11 19, Domestic Water Piping Specialties
8. Section 22 13 16, Sanitary Waste and Vent Piping
9. Section 22 13 19, Sanitary Waste Piping Specialties
10. Section 22 14 01, Drainage System for Structures
11. Section 22 14 10, Pumping Station Piping and Appurtenances
12. Section 22 14 13, Facility Storm Drainage Piping
13. Section 22 14 23, Storm Drainage Piping Specialties
14. Section 22 14 29, Sump Pumps
15. Section 22 33 00, Electric Domestic Water Heaters
16. Section 22 40 00, Plumbing Fixtures
17. Section 25 60 00, Building Management System

1.02 DEFINITIONS

A. Command: When used in the description of a commissioning activity, command means to use the station human machine interface (HMI) for the building management system (BMS) to control systems, equipment and components.

B. Human Machine Interface (HMI): Equipment, software, and functional programming at the locations shown on the Plans and as specified in Division 25 Section Building Management System.

C. Systems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, equipment, and components.

1.03 SYSTEM DESCRIPTION

A. Commissioning work includes: Furnish labor and material to accomplish building commissioning as specified in Division 01 Section “General Commissioning Requirements” and herein, including:

1. Provide to the Commissioning Coordinator preliminary O&M information for use in developing commissioning test procedures.

2. Assist the Commissioning Coordinator in developing commissioning activity procedures and data forms submittals for work specified in this Section.

3. Provide information to the Commissioning Coordinator needed for control interface wiring diagrams submittals for the work of this Section.

4. Perform Level 1 commissioning activities specified in this Section, including installation verification, static tests, start-up, component tests, equipment tests, systems tests.

5. Perform Level 2 commissioning activities specified in this Section, including intrastation system interface tests.

6. Provide support for Level 3 commissioning activities, including jointly with the communications system contractor field testing points in the interface terminal strips, being present during level 3 testing with adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise. When material or equipment provided by this Division is found to be in conflict with specified criteria, adjust or replace said material or equipment, with the assistance of manufacturer as needed.

7. Provide support for Level 4 commissioning activities, including providing adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise during pre-revenue testing.

8. Operate equipment and system during commissioning activities as required by the Commissioning Coordinator.

9. Perform and document commissioning tests to verify readiness for commissioning test demonstration. Commissioning tests are specified herein.

10. Correct issues and repeat commissioning tests when results do not meet acceptance criteria.
11. Commissioning Test Demonstrations: General requirements for commissioning test demonstrations are specified in Division 01 Section 01 91 13, General Commissioning Requirements, Article 3.04, Level 1 and Level 2 Commissioning Activity Commissioning Test Demonstrations.
   a. Repeat commissioning tests on a sample basis to demonstrate acceptable performance: Level 1 Component, Equipment, and System Commissioning Tests, and for Level 2 Intra-station system interface tests.
   b. Record and submit commissioning test demonstration data and issues.
   c. Correct issues and repeat commissioning test demonstration when results do not meet Acceptance Criteria.

12. Attend commissioning meetings as requested by the Commissioning Coordinator.

13. Report any inconsistencies or issues in system operations or performance.

14. Provide personnel to support commissioning test demonstration specified herein as requested by the Commissioning Coordinator.

15. In the event that a commissioning test demonstration fails, assist in determining the cause of failure. Make corrections as necessary.

16. Cooperate with Commissioning Coordinator to make equipment and systems ready for commissioning tests specified herein as early in the construction schedule as possible.

B. Cooperate with Commissioning Coordinator to accomplish commissioning work on schedule and in coordination with other trades.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT
   A. Provide test equipment and instrumentation, including consumable supplies, required to execute commissioning activities. Unless noted otherwise, test equipment and instrumentation remain the property of the Contractor.

2.02 PROPRIETARY TEST INSTRUMENTS
   A. Provide proprietary test instruments or tools required by the equipment manufacturer. Provide and operate the proprietary test instruments or tools as required for commissioning work.

PART 3 - EXECUTION

3.01 LEVEL 1 COMMISSIONING ACTIVITIES REQUIREMENTS
   A. Level 1 commissioning activities scope: Technical requirements for commissioning of plumbing are specified herein.
B. Provide technicians, instrumentation, and tools to perform commissioning activities in accordance with accepted commissioning activity procedures at the direction of the Commissioning Coordinator.

C. Scope of plumbing commissioning activities applies to all portions of the plumbing installation described in the test. Where sampling is specified, it applies only to the commissioning test demonstration.

D. Preparation

1. Certify that plumbing systems, equipment, and materials have been completed, calibrated, and started; and are operating in accordance with Contract Documents.

2. Testing Instrumentation: Install measuring instruments and logging devices to record test data in accordance with accepted commissioning test procedures as directed by the Commissioning Authority.

3. Certify that plumbing instrumentation and control systems have been completed and calibrated; are operating according to the Contract Documents; and that pretest set points have been recorded.

4. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions) in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator.

E. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions.

F. Perform tests using design conditions whenever possible.

G. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Provide equipment to simulate loads. Set simulated conditions in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator. Document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

H. Request approval to alter set points when simulating conditions is not practical.

I. Request approval to alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.

J. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Sound Transit. After deficiencies are resolved, reschedule tests.

K. Where seasonal testing is specified, complete appropriate initial commissioning tests and documentation within the Construction Period. Schedule and execute seasonal tests when specified conditions are expected.

3.02 LEVEL 1 AND LEVEL 2 COMMISSIONING ACTIVITY PROCEDURES

A. Submit level 1 commissioning activity test procedures and data forms for the following types of commissioning activities, requirements for which are specified herein.

1. Level 1 commissioning activities:
a. Installation verification
b. Static tests
c. Start-up procedures
d. Component tests
e. Equipment tests
f. System tests

B. Cooperate with the Commissioning Coordinator to develop level 2 commissioning activity test procedures and data forms related to the work of this Division. Provide information as needed, including interfaces with equipment and systems installed by others.

1. Level 2 commissioning activities:
   a. Intra-station system interface tests

3.03 LEVEL 1 INSTALLATION VERIFICATION CHECKLIST REQUIREMENTS

A. Scope: Installation verification requirements apply to the following:

1. Section 22 05 19, Meters and Gages for Plumbing Piping
2. Section 22 05 23, General- Duty Valves for Plumbing Piping
3. Section 22 05 33, Heat Tracing For Plumbing Piping
4. Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment
5. Section 22 11 16, Domestic Water Piping
6. Section 22 11 19, Domestic Water Piping Specialties
7. Section 22 13 16, Sanitary Waste and Vent Piping
8. Section 22 13 19, Sanitary Waste Piping Specialties
9. Section 22 14 01, Drainage System for Structures
10. Section 22 14 10, Pumping Station Piping and Appurtenances
11. Section 22 14 13, Facility Storm Drainage Piping
12. Section 22 14 23, Storm Drainage Piping Specialties
13. Section 22 14 29, Sump Pumps
14. Section 22 33 00, Electric Domestic Water Heaters
15. Section 22 40 00, Plumbing Fixtures

B. Installation Verification Scope: Technical requirements for Installation Verification of plumbing are specified herein.

C. Installation verification checklist forms shall include the following:
1. Organized to prompt the installer to check off quality criteria for each discrete portion of the Work.

2. Identify the system or features to which the installation verification checklist applies at the top of the form.

3. Section for verification of delivery of accepted materials.

4. Section for condition of materials at delivery.

5. Section for installation. Include manufacturer’s installation instructions.

6. Space at the end of the form for the installer to print their name and company name, fill in the date, and sign or initial.

7. Space to identify the area of work for which the installer is executing the Installation Verification Checklist.

8. Description of the quality criteria as it pertains to the specific work. Include a check-box for each criterion.

D. Quality Criteria: Installation verification checklists shall address the following quality criteria.

1. Make and model match accepted submittals, including for motors, full load amperage rating and winding insulation class.

2. Equipment is installed without visible damage.

3. Location is as indicated on drawings.

4. Equipment is accessible for maintenance using safe work practices.

5. There is sufficient space to remove and replace components intact without demolishing other work.

6. Equipment surfaces are clean and free of dust, dirt, oil and other contaminants.

7. Equipment is accessible for adjustment, maintenance, and testing, including replacement of components or the entire assembly.

8. Piping is properly supported and seismically braced.

9. Equipment is installed level, or pitched per manufacturer’s requirements.

10. Waste and vent piping is installed with required pitch without reverse pitch.

11. Vibration isolation devices are adjusted to required static deflection and support the equipment level.

E. Fill out and sign installation verification checklists for plumbing while the Work is being installed. The intent is for the installing tradesperson to fill out and sign the installation verification checklist as work proceeds to improve the quality of the installation. Retain completed installation verification checklists on site for review.

F. Before performing a commissioning test, submit completed installation verification checklists for work included in the commissioning test.
3.04 LEVEL 1 INSTALLATION VERIFICATION

A. Installation verification checklists are required for the following, minimum:

1. 2208-IV-01 Meters and Gages for Plumbing Piping
   a. Metal-case, liquid-in-glass thermometers
   b. Bimetallic-actuated dial thermometers
   c. Pressure gages

2. 2208-IV-02 Domestic Water Piping
   a. Domestic water piping

3. 2208-IV-03 Domestic Water Piping Specialties
   a. Reduced pressure backflow preventers
   b. Double check valves
   c. Water pressure reducing valves - water regulators
   d. Trap-seal primer valves

4. 2208-IV-04 Sanitary Waste and Vent Piping
   a. Sanitary waste and vent piping

5. 2208-IV-05 Drainage System for Structures
   a. Tunnel track drainage system

6. 2208-IV-06 Pumping Station Piping And Appurtenances
   a. Drainage pumping station piping and appurtenances

7. 2208-IV-07 Facility Storm Drainage Piping
   a. Storm drainage piping

8. 2208-IV-08 Sump Pumps
   a. Pumps and pump controls for the tunnel track drainage pump station
   b. Pump controller: spare point capacity, expandability

9. 2208-IV-09 Sump Pumps
   a. Pumps and pump controls for the sanitary sewage pump station

10. 2208-IV-10 Sump Pumps
    a. Pumps and pump controls for the Packaged Submersible Wastewater Pump Unit

11. 2208-IV-11 Electric Domestic Water Heaters
    a. Electric domestic water heater and controls
12. 2208-IV-12 Heat Tracing for Plumbing, including
   a. Heating cable installation, securement, termination.
   b. Heater trace circuit controller.
   c. Remote temperature sensor.

3.05 LEVEL 1 STATIC TESTS

A. 2208-ST-01: Water Piping Leak Test
   1. System/Equipment to be Tested:
      a. Domestic water piping, Section 22 11 16 Domestic Water Piping.
   2. Functions to be Tested:
      a. See “Test domestic water piping” under Section 22 11 16 Domestic Water Piping.
   3. Conditions of the Test:
      a. See “Test domestic water piping” under Section 22 11 16 Domestic Water Piping.
   4. Acceptable Results:
      a. See “Test domestic water piping” under Section 22 11 16 Domestic Water Piping.

B. 2208-ST-02: Sanitary Waste and Vent Pipe Leak Test
   1. System/Equipment to be Tested:
   2. Functions to be Tested:
      a. Leakage under gravity pressure.
   3. Conditions of the Test:
      a. Test shall be successfully completed before covering piping.
      b. Plug openings and fill system with water such that all pipe joints and fittings are subjected to 10 feet of water head pressure. Exception: piping that penetrates the roof shall be filled to fullest height.
      c. One hour after the system or section has been filled, visually inspect the piping for evidence of leakage.
      d. Include in Static Test Procedures and Data Forms submittal:
         1) Leakage testing plan showing how piping will be divided if testing will be performed in sections.
   4. Acceptable Results:
a. No visible evidence of leakage.

C. 2208-ST-03: Tunnel Track Drainage Pipe Leak Test

1. System/Equipment to be Tested:
   a. Tunnel track drainage piping, Section 22 14 01 Drainage System for Structures.

2. Functions to be Tested:
   a. Leakage under gravity pressure.

3. Conditions of the Test:
   a. Test shall be successfully completed before covering piping.
   b. Plug openings and fill system with water such that all pipe joints and fittings are subjected to 22 to 30 feet of water head pressure. Exception: piping that penetrates the roof shall be filled to fullest height.
   c. Thirty minutes after the system or section has been filled, visually inspect the piping for evidence of leakage.
   d. Include in Static Test Procedures and Data Forms submittal:
      1) Leakage testing plan showing how piping will be divided if testing will be performed in sections.

4. Acceptable Results:
   a. No visible evidence of leakage.

D. 2208-ST-04: Tunnel Track Drainage Pumping Station Piping Leak Test

1. System/Equipment to be Tested:
   a. Tunnel Track Drainage Pumping Station Piping, Section 22 14 10 Tunnel Track Drainage Pumping Station Piping and Appurtenances.

2. Functions to be Tested:
   a. Leakage under pressure.

3. Conditions of the Test:
   a. Perform test per requirements of Section 22 14 10 Tunnel Track Drainage Pumping Station Piping and Appurtenances, Article 3.02.A, Hydrostatic Test.
   b. Include in Static Test Procedures and Data Forms submittal:
      1) Leakage testing plan showing how piping will be divided if testing will be performed in sections.

4. Acceptable Results:
   a. Pressure drop over the test period is five psi or less.
E. 2208-ST-05: Storm Drainage Pipe Leak Test

1. System/Equipment to be Tested:
   a. Storm drainage piping, Section 22 14 13 Facility Storm Drainage Piping.

2. Functions to be Tested:
   a. Leakage under gravity pressure.

3. Conditions of the Test:
   a. Test storm drainage piping according to procedures of Resident Engineer and the Seattle Utility code authorities having jurisdiction (AHJ).
   b. Test shall be successfully completed before covering piping.
   c. Plug openings and fill system with water such that all pipe joints and fittings are subjected to 10 feet of water head pressure. Exception: piping that penetrates the roof shall be filled to fullest height.
   d. After the test duration required by the AHJ, visually inspect the piping for evidence of leakage.
   e. Include in Static Test Procedures and Data Forms submittal:
      1) Leakage testing plan showing how piping will be divided if testing will be performed in sections.

4. Acceptable Results:
   a. No visible evidence of leakage.

3.06 LEVEL 1 START-UP

A. 2208-SU-01: Domestic Water Heater Start-up

1. System/Equipment to be Tested:
   a. Domestic water heater N05-WH-01 and N05-WH-02, and associated controls.

2. Functions to be Tested:
   a. Installation per Water Heater Installation under Section 22 33 00 Electric Domestic Water Heaters.
   b. Installation and start-up per manufacturer’s recommendations.

3. Conditions of the Test:
   a. Perform start-up according to manufacturer’s procedures. Start-up by manufacturer-authorized personnel. Use manufacturer’s data forms to record start-up results.

4. Acceptable Results:
   a. Installation and start-up meet the manufacturer’s requirements.
B. 2208-SU-02: Track Drainage Pumps

1. System/Equipment to be Tested:
   a. Track Drainage Pumps N04-SP-01, N04-SP-02, N04-SP-03, N05-SP-01, N05-SP-02, N05-SP-03, and associated pump controls for the tunnel track drainage pump station, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Installation per Section 22 14 29 Sump Pumps.
   b. Installation and start-up per manufacturer’s recommendations.

3. Conditions of the Test:
   a. Perform start-up according to manufacturer’s procedures. Start-up by manufacturer-authorized personnel. Use manufacturer’s data forms to record start-up results.

4. Acceptable Results:
   a. Installation and start-up meet the manufacturer’s requirements.

C. 2208-SU-03: Submersible Sewage Pumps

1. System/Equipment to be Tested:
   a. Submersible Sewage Pumps N05-SP-04, N05-SP-05, N05-SP-06 and associated pump controls.

2. Functions to be Tested:
   a. Installation per Section 22 14 29 Sump Pumps.
   b. Installation and start-up per manufacturer’s recommendations.

3. Conditions of the Test:
   a. Perform start-up according to manufacturer’s procedures. Start-up by manufacturer-authorized personnel. Use manufacturer’s data forms to record start-up results.

4. Acceptable Results:
   a. Installation and start-up meet the manufacturer’s requirements.

D. 2208-SU-04: Packaged Submersible Wastewater Pump Unit

1. System/Equipment to be Tested:
   a. Packaged Submersible Wastewater Pump Units N05-SP-07, N05-SP-08, N05-SP-09, and associated controls.

2. Functions to be Tested:
   a. Installation per Section 22 14 29 Sump Pumps.
   b. Installation and start-up per manufacturer’s recommendations.
3. Conditions of the Test:
   a. Perform start-up according to manufacturer’s procedures. Start-up by manufacturer-authorized personnel. Use manufacturer’s data forms to record start-up results.

4. Acceptable Results:
   a. Installation and start-up meet the manufacturer’s requirements.

3.07 LEVEL 1 COMPONENT TESTS

A. 2208-C-01: Water Pressure Gauge Calibration

1. System/Equipment to be Tested:
   a. Fluid pressure gauges in plumbing systems, Section 22 05 19 Meters and Gages for Plumbing Piping.

2. Functions to be Tested:
   a. Accuracy of fluid pressure indication.

3. Conditions of the Test:
   a. Systems in which pressure gauges are installed shall operate at their normal flow rates and pressures during the test.

   1) Subject pressure gauge to pressure at or near the high pressure at which the system is scheduled to operate. Subject calibration instrument to the same pressure. Record pressures indicated by both instruments.

   2) Subject pressure gauge to pressure at or near the low pressure at which the system is scheduled to operate. Subject calibration instrument to the same pressure. Record pressures indicated by both instruments.

   3) With system pressure stable, install calibration instrument in place of the pressure gauge. Record calibration instrument pressure. Install the pressure gauge in the same location. Record pressure gauge pressure.

4. Acceptable Results:
   a. Pressure gauge pressures recorded at each stage shall be within ±2.0% of calibration instrument pressures.

B. 2208-C-02: Trap Primers

1. System/Equipment to be Tested:
   a. Trap seal primer valve stations and controls, Section 22 11 19 Domestic Water Piping Specialties.

2. Functions to be Tested:
   a. Priming of floor drain traps.
b. Control timer operation

3. Conditions of the Test:
   a. Operate each trap primer station by activating the override. Observe and record results at each primed drain.
   b. Observe operation of each trap primer station timer.

4. Acceptable Results:
   a. Each primed floor drain trap receives water from the trap primer when the override is actuated.
   b. Trap primer valve opens for 10 seconds once in 24 hours.

C. 2208-C-03: Backflow Preventers

1. System/Equipment to be Tested:
   a. Reduced-Pressure-Principle Backflow Preventers in plumbing systems, Section 22 11 19 Domestic Water Piping Specialties.
   b. Double-Check Backflow Prevention Assemblies in plumbing systems, Section 22 11 19 Domestic Water Piping Specialties.

2. Functions to be Tested:
   a. Backflow assembly functions mandated by the authority having jurisdiction (AHJ).

3. Conditions of the Test:
   a. Perform field test of backflow preventers in accordance with requirements of the local AHJ.

4. Acceptable Results:
   a. Backflow preventer functions as required by AHJ.

D. 2208-C-04: Actuated Drain Valves

1. System/Equipment to be Tested:
   a. Pumping station actuated drain valves (N05-EVLE-XX), 22 14 10, Pumping Station Piping and Appurtenances.

2. Functions to be Tested:
   a. Opening and closing of valves.

3. Conditions of the Test:
   b. Command valve open for 10 seconds.
   c. Command valve closed.
4. Acceptable Results:
   a. Valve closes and does not leak when force main is filled.
   b. Valve opens and water drains freely.
   c. Valve closes and does not leak.

E. 2208-C-05: Water Pressure-Reducing Valves

1. System/Equipment to be Tested:
   a. Water Regulators in plumbing systems, Section 22 11 19 Domestic Water Piping Specialties.

2. Functions to be Tested:
   a. Control of outlet pressure under varying flows.

3. Conditions of the Test: During the test, ensure that only test personnel operate water valves in the system.
   a. With all valves closed, observe water pressure downstream of regulators.
   b. Open one lavatory valve. Observe water pressure downstream of regulators for one minute.
   c. Open sufficient valves to increase flow to approximately 10 percent of design flow. Observe water pressure downstream of regulators for one minute.
   d. Open sufficient valves to increase flow to approximately 50 percent of design flow. Observe water pressure downstream of regulators for one minute.
   e. Continue opening valves to increase flow to approximately 100 percent of design flow. Observe water pressure downstream of regulators for one minute.

4. Acceptable Results:
   a. For all conditions, downstream pressure is stable within ±2 PSI of setpoint (60 PSI initially).

3.08 LEVEL 1 EQUIPMENT TESTS

A. 2208-E-01: Sump Pump Controller

1. System/Equipment to be Tested:
   a. Track Drainage Pumps N04-SP-01, N04-SP-02, N04-SP-03 controls for the tunnel track drainage pump station, 22 14 29 Sump Pumps.
   b. Track Drainage Pumps N05-SP-01, N05-SP-02, N05-SP-03 and associated pump controls for the tunnel track drainage pump station, 22 14 29 Sump Pumps.
c. Sanitary Sewage Pumps N05-SP-04, N05-SP-05, N05-SP-06 and associated pump controls for sanitary sewage pump stations, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Pump controller digital point LED display.
   b. Pump controller analog point display.
   c. Pump controller operator interface display.

3. Conditions of the Test:
   a. Switch the status of each digital point and observe the corresponding LED display.
   b. Vary the input or output value of each analog point and observe the corresponding display.
   c. Demonstrate dynamic display of process parameters, process equipment and all associated controlled and monitored process variables being monitored by the PLC processor.
   d. Modify a randomly selected sample of ten process parameters being monitored by the PLC processor. Restore original values at the completion of the step.

4. Acceptable Results:
   a. LED display is present and correctly reflects status of digital points.
   b. Display is present and correctly reflects value of analog points.
   c. Process parameters, process equipment and all associated controlled and monitored process variables display correct dynamic values.
   d. Selected parameters are capable of being changed and saved to memory.

B. 2208-E-02: Sump Pump Operation

1. System/Equipment to be Tested:
   a. Track Drainage Pumps N04-SP-01, N04-SP-02, N04-SP-03 and associated pump controls for the tunnel track drainage pump station, 22 14 29 Sump Pumps.
   b. Sanitary Sewage Pumps N05-SP-04, N05-SP-05, N05-SP-06 and associated pump controls for sanitary sewage pump stations, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Sump pump control and alarm functions.
   b. Volumetric flow rate performance of sump pumps.

3. Conditions of the Test:
a. Determine water volume in sump between high level alarm signal level and low level cutoff level. Measure volumetric flow rate and head pressures for each pump operating alone.

b. Measure volumetric flow rate and head pressures for each combination of pumps operating together as follows.
   1) N04-SP-01 and N04-SP-03
   2) N04-SP-01 and N04-SP-02
   3) N04-SP-01, N04-SP-02, and N04-SP-03
   4) N05-SP-01 and N05-SP-03
   5) N05-SP-01 and N05-SP-02
   6) N05-SP-01, N05-SP-02, and N05-SP-03
   7) N05-SP-04 and N05-SP-05

c. With all pumps disabled, verify rising water levels at which each pump is commanded to start, and the level at which the high level alarm signal is initiated at the pump control panel.

d. With one pump enabled, verify falling water levels at which the high level alarm signal is cancelled and the level at which each pump is commanded to stop.

4. Acceptable Results:
   a. Volumetric flow rate is within ±5 percent of scheduled value.
   b. Volumetric flow rate is within ±5 percent of scheduled value for each combination of pumps.
   c. Switch and alarm action occurs within ±1.0 inch of scheduled level.
   d. Switch and alarm action occurs within ±1.0 inch of scheduled level.

C. 2208-E-03:Sump Pump Removal and Reinstallation

1. System/Equipment to be Tested:
   a. Track Drainage Pumps N04-SP-01, N04-SP-02, N04-SP-03 and associated pump controls for the tunnel track drainage pump station, 22 14 29 Sump Pumps.
   b. Sanitary Sewage Pumps N05-SP-04, N05-SP-05, N05-SP-06 and associated pump controls for sanitary sewage pump stations, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Ability to remove sump pump from sump without entering sump.
   b. Ability to reinstall sump pump in sump without entering sump.
3. Conditions of the Test: Prerequisite:
   a. Following manufacturer's instructions, remove sump pump from sump without entering sump.
   b. Following manufacturer's instructions, reinstall sump pump in sump without entering sump.
   c. Restore automatic control equipment and functions to normal operating condition. Fill the sump with water until the pump starts automatically. Measure the pump-down time.

4. Acceptable Results:
   a. Pump removal, using manufacturer's recommended tools and methods, proceeds without incident.
   b. Pump reinstallation, using manufacturer's recommended tools and methods, proceeds without incident.
   c. Pump starts and stops automatically. Pump runs normally. Pump-down time is the same as noted during Level 1 test 2208-E-02, Sump Pump Operation

D. 2208-E-04: Packaged Submersible Wastewater Pump Unit – Equipment

1. System/Equipment to be Tested:
   a. Packaged submersible wastewater sump pumps N05-SP-07, N05-SP-08, N05-SP-09, and associated controls.

2. Functions to be Tested:
   a. Sump pump control and alarm functions.
   b. Volumetric flow rate performance of sump pumps.
   c. Oil detection control.

3. Conditions of the Test:
   a. Determine water volume in sump between high level alarm signal level and low level cutoff level. Measure volumetric flow rate and head pressures for each pump operating alone.
   b. With pump disabled, verify rising water levels at which pump is commanded to start, and the level at which the high level alarm signal is initiated at the pump control panel.
   c. With pump enabled, verify falling water level at which the high level alarm signal is cancelled and the level at which pump is commanded to stop.
   d. Introduce lighter-than-water oil into sump. Add water to sump until the mixture exceeds the pump-on level.

4. Acceptable Results:
a. Volumetric flow rate is within $\pm 5$ percent of scheduled value.

b. Switch and alarm action occurs within $\pm 1.0$ inch of scheduled level.

c. Switch and alarm action occurs within $\pm 1.0$ inch of scheduled level.

d. Pump controller prevents pump operation due to oil in sump. Alarm horn sounds when oil is detected and alarm is sent to BMS.

E. 2208-E-05: Heat Tracing Control for Plumbing

1. System/equipment to be tested:

   a. Self-Regulating, Parallel-Resistance Heating Cables

   b. Heater Trace Circuit Controller

2. Functions to be tested:

   a. Response to ambient temperature below freeze protection setpoint.

   b. Heating cable fault alarm.

3. Conditions of the test:

   a. Subject temperature sensor to temperature approximately 3 degrees F above freeze protection setpoint (initial setpoint 41 degrees F). Monitor sensed temperature with a calibration-grade thermometer. Gradually change setpoint or sensed temperature until freeze protection circuit is energized.

   b. Subject temperature sensor to temperature approximately 3 degrees F below freeze protection setpoint (initial setpoint 41 degrees F). Monitor sensed temperature with a calibration-grade thermometer. Gradually change setpoint or sensed temperature until freeze protection circuit is deenergized.

   c. Simulate an electrical fault on the heating cable.

4. Acceptance Criteria:

   a. Freeze protection circuit is energized at setpoint temperature minus 2 degrees F.

   b. Freeze protection circuit is deenergized at setpoint temperature plus 2 degrees F.

   c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at BMS panel.

3.09 LEVEL 1 SYSTEM TESTS

A. 2208-S-01: Track Drainage Pumps

1. System/Equipment to be Tested:

   a. Track Drainage Pumps:
2. Functions to be Tested:
   a. Sequence of operation.

3. Conditions of the Test: At the Contractor's option, this test may be performed in conjunction with Division 25 Section 25 08 00, Commissioning of Integrated Automation, Article 3.09.E, 2508-S-05: CP-18 Track Drainage Pump Station Control. Start the test with all controls in normal, automatic control, and all pumps enabled. Pumps may be temporarily disabled while filling the sump to the required level.
   a. Sump fluid level below the "Low Level Alarm" level. Lead pump: N04-SP-03.
   b. Sump fluid level above the "Low Level Alarm" level and below the first pump "On" level.
   c. Sump fluid level above the first pump "On" level and below the second pump "On" level.
   d. Disconnect communication link with BMS. Wait indicated time period (five minutes initially) after the pump stopped in the previous condition to allow time for the actuated drain valve to operate.
   e. Sump fluid level above the second pump "On" level and below the third pump "On" level.
   f. Sump fluid level above the third pump "On" level and below the "High Water Alarm" level.
   g. Restore communication link with BMS. Sump fluid level above the "High Water Alarm" level.
   h. Initiate five more On/Off cycles of the lead pump to demonstrate the rotation of the large pump as lead on each third cycle. Manipulation of the "All Pumps Off" switch is acceptable to minimize time and water use.
   i. Verify response to failure of a pump by failing each pump in turn while it is operating as the lead pump. Restore each pump to normal control after verifying response to failure and before failing the next pump.

4. Acceptable Results:
   a. "Low Level Alarm" is activated and communicated to the BMS. All pumps are "Off."
   b. "Low Level Alarm" is cleared and communicated to the BMS. All pumps are "Off."
   c. Lead pump is "On," and "Stops" after water level falls below the "All Pumps Off" level. The lead pump is N04-SP-03.
   d. Loss of communication with BMS does not impair specified local control functions. Actuated drain valve opens after the indicated time period and remains open for the indicated time period.
   e. Lead pump and the first lag pump are "On," and "Stop" after water level falls below the "All Pumps Off" level. The lead pump is N04-SP-03.
f. Lead pump, first lag pump, and second lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The lead pump is N04-SP-01.

g. Restoration of communication link with BMS does not impair control. The “High Water Alarm” is activated and communicated to the BMS. Lead pump, first lag pump, and second lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The “High Water Alarm” is cleared and communicated to the BMS after water level falls below “High Water Alarm” level. The lead pump is N04-SP-03.

h. Four On/Off cycles have been observed in preceding steps. The following are the correct lead pumps for cycles #5 through #9:

1) Cycle # 5: The lead pump is N04-SP-03.
2) Cycle # 6: The lead pump is N04-SP-02.
3) Cycle # 7: The lead pump is N04-SP-03.
4) Cycle # 8: The lead pump is N04-SP-03.
5) Cycle # 9: The lead pump is N04-SP-01.

i. When a pump fails, the next pump in the operating sequence shall start and a common alarm shall be annunciated at the BMS and available for communication to LCC.

B. 2208-S-02: Track Drainage Pumps– System

1. System/Equipment to be Tested:
   a. Track Drainage Pumps and associated pump controls for the tunnel track drainage pump station, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Sequence of operation.

3. Conditions of the Test: Start the test with all controls in normal, automatic control, and all pumps enabled. Pumps may be temporarily disabled while filling the sump to the required level.
   a. Sump fluid level below the “Low Level Alarm” level. Lead pump: N05-SP-03.
   b. Sump fluid level above the “Low Level Alarm” level and below the first pump “On” level.
   c. Sump fluid level above the first pump “On” level and below the second pump “On” level.
   d. Disconnect communication link with BMS. Wait indicated time period (five minutes initially) after the pump stopped in the previous condition to allow time for the actuated drain valve to operate.
   e. Sump fluid level above the second pump “On” level and below the third pump “On” level.
f. Sump fluid level above the third pump “On” level and below the “High Water Alarm” level.

g. Restore communication link with BMS. Sump fluid level above the “High Water Alarm” level.

h. Initiate five more On/Off cycles of the lead pump to demonstrate the rotation of the large pump as lead on each third cycle. Manipulation of the “All Pumps Off” switch is acceptable to minimize time and water use.

i. Verify response to failure of a pump by failing each pump in turn while it is operating as the lead pump. Restore each pump to normal control after verifying response to failure and before failing the next pump.

4. Acceptable Results:

a. “Low Level Alarm” is activated and communicated to the BMS. All pumps are “Off.”

b. “Low Level Alarm” is cleared and communicated to the BMS. All pumps are “Off.”

c. Lead pump is “On,” and “Stops” after water level falls below the “All Pumps Off” level. The lead pump is N05-SP-03.

d. Loss of communication with BMS does not impair local control. Actuated drain valve opens after the indicated time period and remains open for the indicated time period.

e. Lead pump and the first lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The lead pump is N05-SP-03.

f. Lead pump, first lag pump, and second lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The lead pump is N05-SP-03.

g. Restoration of communication link with BMS does not impair control. The “High Water Alarm” is activated and communicated to the BMS. Lead pump, first lag pump, and second lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The “High Water Alarm” is cleared and communicated to the BMS after water level falls below “High Water Alarm” level. The lead pump is N05-SP-03.

h. Four On/Off cycles have been observed in preceding steps. The following are the correct lead pumps for cycles #5 through #9:

1) Cycle # 5: The lead pump is N05-SP-03.
2) Cycle # 6: The lead pump is N05-SP-02.
3) Cycle # 7: The lead pump is N05-SP-03.
4) Cycle # 8: The lead pump is N05-SP-03.
5) Cycle # 9: The lead pump is N05-SP-01.
i. When a pump fails, the next pump in the operating sequence shall start and a common alarm shall be annunciated at the Operations Control Center.

C. 2208-S-03: Sanitary Sewage Pumps at N5-5P12 – System

1. System/Equipment to be Tested:
   a. Track Drainage Pumps N05-SP-04, N05-SP-05, and associated pump controls for the sanitary sewage pump station at N5-5P12, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Sequence of operation.

3. Conditions of the Test: Start the test with all controls in normal, automatic control, and all pumps enabled. Pumps may be temporarily disabled while filling the sump to the required level.
   a. Sump fluid level below the “Low Level Alarm” level. Lead pump: N05-SP-04.
   b. Sump fluid level above the “Low Level Alarm” level and below the first pump “On” level.
   c. Disconnect communication link with BMS. Sump fluid level above the first pump “On” level and below the second pump “On” level.
   d. Sump fluid level above the second pump “On” level and below the “High Water Alarm” level.
   e. Restore communication link with BMS. Sump fluid level above the “High Water Alarm” level.
   f. Verify response to failure of a pump by failing each pump in turn while it is operating as the lead pump. Restore each pump to normal control after verifying response to failure and before failing the next pump.

4. Acceptable Results:
   a. “Low Level Alarm” is activated and communicated to the BMS. All pumps are “Off.”
   b. “Low Level Alarm” is cleared and communicated to the BMS. All pumps are “Off.”
   c. Loss of communication with BMS does not impair local control. Lead pump is “On,” and “Stops” after water level falls below the “All Pumps Off” level. The lead pump is N05-SP-04.
   d. Lead pump, and lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The lead pump is N05-SP-05.
   e. Restoration of communication link with BMS does not impair control. The “High Water Alarm” is activated and communicated to the BMS. Lead pump and lag pump are “On,” and “Stop” after water level falls below the “All Pumps Off” level. The “High Water Alarm” is cleared and
communicated to the BMS after water level falls below “High Water Alarm” level. The lead pump is N05-SP-04.

f. When a pump fails, the next pump in the operating sequence shall start and a common alarm shall be annunciated at the Operations Control Center.

D. 2208-S-04: Sanitary Sewage Pump at N5-5P19 – System

1. System/Equipment to be Tested:
   a. Track Drainage Pump N05-SP-06, and associated pump controls for the sanitary sewage pump station at N5-5P19, 22 14 29 Sump Pumps.

2. Functions to be Tested:
   a. Sequence of operation.

3. Conditions of the Test: Start the test with all controls in normal, automatic control, and pump enabled. Pump may be temporarily disabled while filling the sump to the required level.

   a. Sump fluid level below the “Low Level Alarm” level.
   b. Sump fluid level above the “Low Level Alarm” level and below pump “On” level.
   c. Disconnect communication link with BMS. Sump fluid level above pump “On” level and below the “High Water Alarm” level.
   d. Restore communication link with BMS. Sump fluid level above the “High Water Alarm” level.
   e. Verify response to failure of pump by failing pump while it is operating. Restore pump to normal control after verifying response to failure.

4. Acceptable Results:
   a. “Low Level Alarm” is activated and communicated to the BMS. Pump is “Off.”
   b. “Low Level Alarm” is cleared and communicated to the BMS. Pump is “Off.”
   c. Loss of communication with BMS does not impair local control. Pump is “On,” and “Stops” after water level falls below the “Pump Off” level.
   d. Restoration of communication link with BMS does not impair control. The “High Water Alarm” is activated and communicated to the BMS. Pump is “On,” and “Stops” after water level falls below the “Pump Off” level. The “High Water Alarm” is cleared and communicated to the BMS after water level falls below “High Water Alarm” level.
   e. When pump fails, a common alarm shall be annunciated at the Operations Control Center.

E. 2208-S-05: Packaged Submersible Wastewater Pump Unit – System
1. System/Equipment to be Tested:
   a. Packaged submersible wastewater sump pumps N05-SP-07, N05-SP-08, N05-SP-09, and associated controls.

2. Functions to be Tested:
   a. Sequence of control.

3. Conditions of the Test: Start the test with all controls in normal, automatic control, and pump enabled. Pump may be temporarily disabled while filling the sump to the required level.
   a. Sump fluid level below the "Low Level Alarm" level.
   b. Sump fluid level above the "Low Level Alarm" level and below pump "On" level.
   c. Disconnect communication link with BMS. Sump fluid level above pump "On" level and below the "High Water Alarm" level.
   d. Restore communication link with BMS. Sump fluid level above the "High Water Alarm" level.
   e. Verify response to failure of pump by failing pump while it is operating. Restore pump to normal control after verifying response to failure.

4. Acceptable Results:
   a. "Low Level Alarm" is activated and communicated to the BMS. Pump is "Off."
   b. "Low Level Alarm" is cleared and communicated to the BMS. Pump is "Off."
   c. Loss of communication with BMS does not impair local control. Pump is "On," and "Stops" after water level falls below the "Pump Off" level.
   d. Restoration of communication link with BMS does not impair control. The "High Water Alarm" is activated and communicated to the BMS. Pump is "On," and "Stops" after water level falls below the "Pump Off" level. The "High Water Alarm" is cleared and communicated to the BMS after water level falls below "High Water Alarm" level.
   e. When pump fails, a common alarm shall be annunciated at the Operations Control Center.

3.10 ATTACHMENTS
   A. Attachment A: Example Installation Verification Checklist
   B. Attachment B: Example Commissioning Test

END OF SECTION

ATTACHMENTS
## Installation Verification Checklist
### Sump Pump

#### Model Verification

<table>
<thead>
<tr>
<th>Model Verification</th>
<th>Submitted</th>
<th>Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Manufacturer</td>
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<td></td>
</tr>
<tr>
<td>2. Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Serial Number</td>
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<td></td>
</tr>
<tr>
<td>4. Arrangement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flow, Design (GPM)</td>
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<td></td>
</tr>
<tr>
<td>6. Motor Power / Speed (hp / rpm)</td>
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</tr>
<tr>
<td>7. Voltage / Phase / Frequency (V / Ø / Hz)</td>
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</tr>
<tr>
<td>8. Motor FLA</td>
<td></td>
<td></td>
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<tr>
<td>9. Motor winding insulation class</td>
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<tr>
<td>10.</td>
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</tr>
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#### Physical Checks

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<thead>
<tr>
<th>Physical Checks</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Unit is free from physical damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. All components present and in proper order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Installation and startup manual provided</td>
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<td></td>
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<td>14. Unit tags affixed and legible</td>
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<tr>
<td>15. Unit secured as required by manufacturer and specifications</td>
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<td></td>
</tr>
<tr>
<td>16. Adequate clearance around unit for service</td>
<td></td>
<td></td>
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<tr>
<td>17. All components accessible for maintenance and replacement</td>
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<tr>
<td>18. Unit can be removed from the sump without entering sump</td>
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<tr>
<td>19. Guide rails installed, secured, aligned</td>
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<tr>
<td>20. All fasteners are tight</td>
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<tr>
<td>21.</td>
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</tr>
</tbody>
</table>

#### Piping

<table>
<thead>
<tr>
<th>Piping</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Adequate instrumentation and ports available for testing and balancing of unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. All valves and sensors are accessible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. All valves close tightly and operate fully and easily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Valve handles can be operated without interference from adjacent equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Piping is clean and free of debris</td>
<td></td>
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<tr>
<td>27.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Mechanical

<table>
<thead>
<tr>
<th>Mechanical</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>28. Inspect the equipment for any shipping damage. Remove any foreign material such as tags or packing from any moving parts or from within the pump housing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Compare the voltage, hertz, and phase stamped on the motor with the current characteristics of the line to which the motor is to be connected.</td>
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<tr>
<td>30. Lock out power source at disconnect switch.</td>
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<tr>
<td>31. Turn motor, drive, and impeller by hand to see that no misalignment has taken place in shipment.</td>
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<tr>
<td>32. Check all bolts, screws, and fasteners, and tighten if necessary.</td>
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<tr>
<td>33. Make certain all setscrews, locking collars and bearing mounting bolts are secure.</td>
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<tr>
<td>34. Pump discharge connection to base elbow flange is secure and tight</td>
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</tr>
<tr>
<td>35. Jog the pump electrically and note rotation. Reverse two electrical leads, if necessary, to obtain proper rotation as marked with rotation arrow on fan. Do not allow the impeller to run backwards except momentarily.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. Unit is clean.</td>
<td></td>
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</tr>
<tr>
<td>37. Pump and motor lubricated and aligned.</td>
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<td></td>
</tr>
<tr>
<td>38. Motor and pump shaft aligned.</td>
<td></td>
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<tr>
<td>39.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Electrical

40. Local disconnect installed in accessible location
   Yes  No
41. All electrical connections are tight
   Yes  No
42. All electrical components are grounded
   Yes  No
43. Power and signal cables are properly supported and securely sealed
   Yes  No
44. Motor nameplate matches line characteristics: Voltage / Phase / Frequency (V / Ø / Hz)
   Yes  No

Manufacturer

45. Manufacturer’s installation checklist completed and attached, if appropriate
   Yes  No

"No" Responses

<table>
<thead>
<tr>
<th>Item #</th>
<th>Date</th>
<th>Reason for “No” Response</th>
</tr>
</thead>
</table>

Corrective Action

<table>
<thead>
<tr>
<th>Item #</th>
<th>Date</th>
<th>Corrective Action</th>
<th>Completed By:</th>
</tr>
</thead>
</table>

Signatures: The undersigned have performed the above installation check and verified that the installation is complies with the manufacturer’s and contract requirements.

Company / Print Name / Signature / Date

Installing Contractor: ________________________________

Owner’s witness: ____________________________________

END OF INSTALLATION CHECKLIST
Attachment B: Example Commissioning Test

I OBJECTIVES
A. To verify sewage ejector and sump pump control and alarm functions.
B. To verify volumetric flow rate performance of sewage ejectors and sump pumps.
C. Reference Section _____ and drawing _____ for sewage ejectors.

II SYSTEMS AND EQUIPMENT TO BE TESTED
A. Sewage ejector pump units PS-2 and PS-4, and associated installation and controls.

III PREREQUISITES
A. Final installation of the sanitary sewer system, including startup of sewage ejector pump units.
   ................................................................. Y___ N___
B. System is operating at normal pressure and temperature. ............................................ Y___ N___
C. Documented completion of Construction Observation, including correction of deficient conditions.
   ........................................................................................................... Y___ N___
D. BMS interface with Central Control System, and graphics package complete. ............. Y___ N___
E. The following Division 22 requirements have been completed with acceptable results:
   1. _____3.02 Start-up testing per manufacturer’s requirements .......... Y___ N___
   2. _____3.05 Testing (leak tests) ................................................................. Y___ N___
   3. _____3.02 Start-up testing per manufacturer’s requirements .......... Y___ N___
   4. _____3.05 Testing (leak tests) ................................................................. Y___ N___

IV MINIMUM PARTICIPANTS
A. Owner’s Witness
B. Test Technician: Plumbing System Contractor
C. Test Technician: Temperature Control System Contractor

V TEST EQUIPMENT
A. Stop watch
B. Various hand tools

VI TEST PROCEDURE
In accordance with general conditions of the contract, contractor shall be responsible for
initiating, maintaining, and supervising all safety precautions and programs in connection with
the performance of this test. Stop the test and notify the owner if it is determined that any part
of the test cannot be performed safely.
A. Perform each of the following steps for each sewage ejector unit and for each pump within the
   sewage ejector unit.
B. Basis of Test: The following test is based on the following controls features:
   1. Each pump set consists of 2 pumps, locally controlled with the following functions:
      a. Lead Pump Start/Stop
      b. Lag Pump Start/Stop
      c. Lead Pump Alternation on each cycle (except PS-1)
      d. Lead Pump Failure Alarm
      e. Lag Pump Run Alarm
      f. High Liquid Level Alarm
   2. Pumps are staged on and off in response to four liquid level float sensors:
      a. Level 1: Both pumps OFF
      b. Level 2: Lead pump ON
      c. Level 3: Lead pump ON, Lag pump ON, Lag pump run ALARM.
      d. Level 4: High liquid level ALARM
   3. Flow rate is as scheduled in contract documents.
C. Determine and record on the Data Form the pumped volume for each sump. Obtain sump volume information from the manufacturer or measure the actual volume using a metered pump. If manufacturer’s information is used, verify that it accounts for (deducts) the volume occupied by the pump assemblies.

1. From Level 2 (lead pump on) to Level 1 (both pumps off). Determine the volume of water contained between the level at which the lead pump starts and the level at which the lead pump stops.
2. From Level 3 (both pumps on) to Level 1 (both pumps off). Determine the volume of water contained between the level at which the both pumps start and the level at which the both pumps stop.

D. Calculate and record on the Data Form the Design Pump Cycle Time corresponding to the design rate of flow for the pumped volume.

\[
\text{Time (sec)} = \frac{60 \times \text{[Volume Pumped (gal)]}}{\text{[Design Flow Rate (GPM)]}}
\]

E. Lead Pump Flow: Measure and record on the Data Form the pump run time in seconds for each of three pump-down cycles for each pump running solo. Promptly stop the inflow of liquid to the sump each time the pump starts to ensure the volume pumped in the cycle is no more than the calculated pumped volume.

1. Observe the liquid level in the sump (Inches above or below the mark) to confirm that the pump starts and stops at the levels marked previously. (Acceptance: Pump starts and stops within ¼” of the levels marked previously; Lead pump alternates after each cycle.)
2. Observe and record the pump status reported at the operator’s workstation at the Central Command Center. Confirm that the reported status matches the actual on-off run status at and between each cycle. (Acceptance: Pump status is reported correctly.)

F. Lead Pump plus Lag Pump Flow: Measure and record on the Data Form the pump run time in seconds for each of three pump-down cycles for each pump running as the Lead pump with the Lag pump running (Level 3 switch ON). Disable the Level 2 switch while filling the sump so that the Lead pump and Lag pump start when the Level 3 switch floats. Promptly stop the inflow of liquid to the sump each time the pump starts to ensure the volume pumped in the cycle is no more than the calculated pumped volume.

1. Observe the liquid level in the sump (Inches above or below the mark) to confirm that the pump starts and stops at the levels marked previously. (Acceptance: Pump starts and stops within ¼” of the levels marked previously.)
2. Observe and record the pump status reported at the operator’s workstation at the Central Command Center. Confirm that the reported status matches the actual on-off run status at and between each cycle. (Acceptance: Pump status is reported correctly.)

G. Calculate and record on the Data Form the rate of flow for each pump cycle.

\[
\text{[Measured Flow Rate (GPM)]} = \frac{60 \times \text{[Pumped Volume (gal)]}}{\text{Time (sec)}}
\]

(Acceptance: Calculated flow rate is within 5 percent of scheduled flow.)

H. Calculate and record on the Data Form the error between measured flow rate and the design flow rate for each pump cycle. (Acceptance: Maximum Error = ±5%)

\[
\text{Error (%) } = \frac{100 \times \text{[Design Flow Rate (GPM)]} - \text{[Measured Flow Rate (GPM)]}}{\text{[Design Flow Rate (GPM)]}}
\]

I. By inspection, or by reference to the pump manufacturer’s literature, determine and record on the Data Form the liquid level at which the Level 4 high water alarm switch activates relative to the pump-on mark on the sight glass.

J. Open the electrical disconnects to both pump motors without disabling the pump controls. Allow liquid to accumulate in the sump until the Level 4 switch activates.

1. Observe and record the liquid level at which the Level 4 switch activates. (Acceptance: Level 4 switch activates within ± ¼” of Level 4 switch setpoint.)
2. Observe and record initiation of High Water Alarm at Central Command Station. (Acceptance: An alarm notification at Central Command Station of High Water Level.)
K. Close the electrical disconnects to both pump motors to restore pump operation. Observe and record the change of status of the High Water Alarm at Central Command Station when the level falls below the high level alarm point. (Acceptance: The pump starts immediately when the switch is closed. The High Water Alarm clears only when the level falls below the Level 4 alarm level. Pump status shows run and stop correctly at Central Command Station.)

L. Restore system to full automatic control. Open valves that were closed or throttled.

VII ACCEPTANCE CRITERIA
A. Observed results shall comply with acceptance criteria that appear below each step of the procedure above.

VIII TEST RESULTS
A. Record test conditions and results on the Data Form at the time of the test. Record results legibly in ink.
B. If results do not comply with Acceptance Criteria above, terminate the test, complete a Commissioning Issue Report Form Part 1, make necessary corrections, repeat and document the FPT, submit Commissioning Issue Report Form Part 2, and repeat the FPT Demonstration.
C. Describe any deviation, or elaboration, on the test procedure in the Notes sections. Attach additional pages for notes if necessary.
D. Initial completed lines as each portion of the test is completed and recorded. Sign and date the Data Form when the tests are complete.

END OF TEST PROCEDURE
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for domestic water piping inside the building.

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

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 05 00, Common Work Results for Plumbing
2. Section 22 05 19, Meter and Gages for Plumbing Piping
3. Section 22 05 23, General-Duty Valves for Plumbing Piping
4. Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment
5. Section 22 08 00, Commissioning of Plumbing
6. Section 22 11 19, Domestic Water Piping Specialties
7. Section 22 40 00, Plumbing Fixtures
8. Section 31 20 00, Earth Moving
9. Section 33 11 00, Water Utility Distribution Piping

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society of Mechanical Engineers (ASME)
   a. ASME B16.8 Cast Copper Alloy Solder Joint Pressure Fittings
   b. ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
   c. ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500 and 2500

   a. ASTM B32 Standard Specification for Solder Metal
   b. ASTM B88 Standard Specification for Seamless Copper Water Tube
c. ASTM B813 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

d. ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

3. City of Seattle (COS):
   a. Seattle Fire Code (International Fire Code with Seattle Amendments)

4. Manufacturers Standardization Society for the Valve and Fittings Industry (MSS)
   a. MSS SP-43 Wrought and Fabricated Butt-Welding Fittings for Low Pressure, Corrosion Resistant Applications
   b. MSS SP-44 Steel Pipeline Flanges
   c. MSS SP-69 Pipe Hangers and Supports – Selection and Application
   d. MSS SP-123 Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

5. (NSF)
   a. NSF 61 Drinking Water Components – Health Effects

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Field quality-control test reports.

1.04 QUALITY ASSURANCE
A. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS
A. Refer to Article 3.02, Pipe and Fitting Applications, for applications of pipe, tube, fitting, and joining materials.
B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
3. 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.

D. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.


2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.

3. 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.

2.02 VALVES

A. Bronze and cast-iron, general-duty valves are specified in Section 22 05 23, General-Duty Valves for Plumbing Piping.

B. Balancing and drain valves are specified in Section 22 11 19, Domestic Water Piping Specialties.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Excavating, trenching, and backfilling are specified in Section 31 20 00, Earth Moving.

3.02 PIPE AND FITTING APPLICATIONS

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 may be used on aboveground piping, unless otherwise indicated.

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

D. Under-Building-Slab, Water-Service Piping on Service Side of Water Meter: Refer to Section 33 11 00, Water Utility Distribution Piping.

E. Domestic Water Piping on Service Side of Water Meter inside the Building: Use any of the following piping materials for each size range:

1. NPS 4 to NPS 6: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

F. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 4 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

G. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:

1. NPS 1 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
2. NPS 1-1/4 and NPS 1-1/2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

3. NPS 2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

4. NPS 2-1/2 to NPS 3-1/2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

5. NPS 4 to NPS 6: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

3.03 VALVE APPLICATIONS

A. Contract Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 and larger.

2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.


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 or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 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.

1. Install hose-end drain valves at low points in water mains, risers, and branches.

2. Install stop-and-waste drain valves where indicated.

D. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Section 22 11 19, Domestic Water Piping Specialties.

3.04 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Section 22 05 00, Common Work Results for Plumbing.

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

C. 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 Section 22 05 00, Common Work Results for Plumbing.

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. Pressure gages are
specified in Section 22 05 19, Meter and Gages for Plumbing Piping and drain valves and strainers are specified in Section 22 11 19, Domestic Water Piping Specialties.

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

3.05 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 22 05 00, Common Work Results for Plumbing.

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.06 ROUGHING-IN FOR WATER METERS

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

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

3.07 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support devices are specified in Section 22 05 29, 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: MSS Type 49, spring cushion rolls, if indicated.

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.

B. Install supports according to Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment.

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

D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. **NPS 3 to NPS 5**: 10 feet with 1/2-inch rod.

6. **NPS 6**: 10 feet with 5/8-inch rod.

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

**G.** Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

### 3.08 CONNECTIONS

**A.** Install piping adjacent to equipment and machines to allow service and maintenance.

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

**C.** Connect domestic water piping to water-service piping with shutoff valve, and extend and connect to the following:

1. **Booster Pumps**: Cold-water suction and discharge piping.

2. **Water Heaters**: Cold-water supply 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. Refer to Section 22 40 00, Plumbing Fixtures.

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.

### 3.09 FIELD QUALITY CONTROL

**A.** Inspect domestic water piping as follows:

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 24 hours 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 test or inspection, make required corrections and arrange for reinspection.

4. **Reports**: Prepare inspection reports and have them signed by authorities having jurisdiction.

**B.** Test domestic water piping as follows:
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 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 and inspect. 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 required corrective action.

3.10 CLEANING

A. Clean and disinfect potable domestic water piping using purging and disinfecting procedures prescribed by authorities having jurisdiction.

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

3.11 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Domestic Water Piping systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the following domestic water piping specialties:

1. Backflow preventers.
2. Water pressure-reducing valves.
3. Strainers.
4. Hose bibbs.
5. Drain valves.
7. Trap-seal primer valves.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 05 00, Common Work Results for Plumbing
2. Section 22 05 50, Mechanical Identification
3. Section 22 08 00, Commissioning of Plumbing
4. Section 22 11 16, Domestic Water Piping

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society of Mechanical Engineers (ASME)
   a. ASME B1.20.7 Hose Coupling Screw Threads (Inch)
   b. ASME A112.1.2 Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
   c. ASME A112.18.1 Plumbing Supply Fittings
   d. ASME A112.21.3M Performance Requirements for Backflow Devices and Systems in Plumbing Fixture Fittings

2. American Society of Safety Engineers (ASSE)
a. ASSE 1001 Performance Requirements for Atmospheric Type Vacuum Breakers

b. ASSE 1003 Performance Requirements for Water Pressure Reducing Valves

c. ASSE 1010 Performance Requirements for Water Hammer Arresters

d. ASSE 1011 Performance Requirements for Hose Connection Vacuum Breakers

e. ASSE 1013 Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers

f. ASSE 1015 Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies

g. ASSE 1018 Performance Requirements for Trap Seal Primer Valves – Potable Water Supplied

3. American Water Works Association (AWWA)
   a. AWWA C550 Protective Epoxy Interior Coatings for Valves and Hydrants

4. Manufacturers Standardization Society for the Valve and Fittings Industry
   a. MSS SP-110 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

5. Plumbing and Drainage Institute (PDI)
   a. PDI-WH 201 Water Hammer Arrestors

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

1.04 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each type of product indicated.
C. Field quality-control test reports.
D. Operation and maintenance data.

1.05 QUALITY ASSURANCE
A. NSF Compliance:
PART 2 - PRODUCTS

2.01 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig (860 kPa) minimum, unless otherwise indicated.
   a. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 (DN 65) and larger.
   b. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
   c. Screen: 304 Stainless steel with round perforations, unless otherwise indicated.
   d. Perforation Size:
      1) Strainers NPS 2 and Smaller: 0.020 inch
      2) Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
   e. Drain: Factory-installed, hose-end drain valve.

2.02 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers (RPBP):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Watts Series 909 by Watts Industries, Inc.; Water Products Division, 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. Zurn Plumbing Products Group; Wilkins Div.


3. Operation: Continuous-pressure applications.

4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.

5. Size: as shown on Contract Drawings

6. Design Flow Rate: as shown on Contract Drawings

7. Selected Unit Flow Range Limits: as shown on Contract Drawings
8. Pressure Loss at Design Flow Rate: 10 psig for sizes NPS 2 and smaller; 10 psig for NPS 2-1/2 and larger.

9. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.

10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

11. Configuration: Designed for horizontal, straight through flow.

12. 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.

B. Double-Check Backflow-Prevention Assemblies:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Watts 790DCDA by Watts Industries, Inc.; Water Products Division, 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. Zurn Plumbing Products Group; Wilkins Div.
   3. Operation: Continuous-pressure applications, unless otherwise indicated.
   4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   5. Pressure Loss at Design Flow Rate: 5 psig for sizes NPS 2 and smaller; 5 psig for NPS 2-1/2 and larger.
   6. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.
   7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   8. Configuration: Designed for horizontal, straight through flow.
   9. Accessories:
      a. Valves: 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.
2.03 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Watts 25AUB-Z3 or a comparable product by one of the following Cash Acme.
   a. Conbraco Industries, Inc.
   b. Honeywell Water Controls.
   c. Zurn Plumbing Products Group; Wilkins Div.


3. Pressure Rating: Maximum working pressure of 300 psig.

4. Size: as indicated on drawing or line size if not indicated.

5. Design Inlet Pressure: 195 psi

6. Design Outlet Pressure Setting: 60 psi adjustable

7. Body: Bronze with chrome-plated finish 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.


9. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.04 HOSE BIBBS

A. Hose Bibb in Wall Box HB-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Model 5518 by Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc, or a comparable product by one of the following:
   b. MIFAB, Inc.
   c. Prier Products, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Woodford Manufacturing Company.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.


4. Operation: Loose key.
5. Inlet: NPS 3/4 or NPS 1.

6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

7. Vacuum Breaker: ASSE 1011,

8. Wall Box: Deep, flush mounting with cover.


10. Operating Keys(s): Two with each wall hydrant.

B. Hose Bibb in Floor Box HB-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Model 5811 by Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc, or a comparable product by one of the following:
   b. MIFAB, Inc.
   c. Prier Products, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Woodford Manufacturing Company.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.3M.


5. Depth of Valve Housing: 9-1/2 inches

6. Supply Connections: NPS 1 threaded or solder-joint inlet.


C. Hose Bibbs HB-3:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Series 560 sillcock by Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc, or a comparable product by one of the following:
b. MIFAB, Inc.
c. Prier Products, Inc.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.
f. Woodford Manufacturing Company.
g. Zurn Plumbing Products Group; Specification Drainage Operation.

5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
10. Operator: Wheel handle

2.05 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
   2. Pressure Rating: 400-psig minimum CWP.
   4. Body: Copper alloy.
   5. Ball: Chrome-plated brass.
   8. Inlet: Threaded or solder joint.

2.06 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:
   a. AMTROL, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. PPP Inc.
   e. Sioux Chief Manufacturing Company, Inc.
   g. Tyler Pipe; Wade Div.
   h. Watts Drainage Products Inc.
   i. Zurn Plumbing Products Group; Specification Drainage Operation.


3. Type: Copper tube with piston.

4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.07 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves and system:
   a. 1. Basis-of-Design Product: Subject to compliance with requirements, provide Precision Plumbing Products Prime-Time Electronic Trap Priming Assembly or a comparable product by one of the following: Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.

2. Standard: ASSE 1044,

3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.


5. Electric Controls: 24-hour timer, 10-second flow time, solenoid valve, and manual switch for 120-V ac power circuit breaker and tested and certified per UL#73.

6. Vacuum Breaker: ASSE 1001

7. Number Outlets: As required by the diagram and plans.


9. Manifold: copper tubing ASTM B88


12. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to Section 22 05 00, 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. Install pressure gages on inlet and outlet.

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

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

F. 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.

G. Piping installation requirements are specified in other Section 22 11 16, Domestic Water Piping, and Contract Drawings indicate general arrangement of piping and specialties.

H. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Reduced-pressure-principle backflow preventers.

2. Double-check backflow-prevention assemblies.


4. Supply-type, trap-seal primer valves.

I. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 50, Mechanical Identification.
3.02 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 Seattle Public Utility and the Resident Engineer and the device's reference standard.

2. Set outlet pressure for each water regulator. Test pressure regulator at middle of rated flow and verify outlet pressure is within 2 psig of outlet set point pressure.

3. Document that each trap receives water when trap primer operates.

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

3.03 ADJUSTING

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

3.04 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Domestic Water Piping Specialties systems and equipment See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 22 13 16
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specification for the following soil and waste, sanitary drainage and vent piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 05 00, Common Work Results for Plumbing
2. Section 22 05 23, General-Duty Valves for Plumbing Piping
3. Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment
4. Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment
5. Section 22 08 00, Commissioning of Plumbing
6. Section 22 11 16, Domestic Water Piping
7. Section 22 13 19, Sanitary Waste Piping Specialties

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society for Testing and Materials International (ASTM)
   a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   b. ASTM A74 Standard Specification for Cast Iron Soil Pipe and Fittings
   c. ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
   d. ASTM A733 Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
f. ASTM B32 Standard Specification for Solder Metal

g. ASTM B306 Standard Specification for Copper Drainage Tube (DWV)

h. ASTM B813 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

i. ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

j. ASTM C564 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings


2. American Society of Sanitary Engineering (ASSE)
   a. ASSE 1043 Performance Requirements for Cast Iron Sovent Sanitary Drainage Systems

3. Manufacturers Standardization Society (MSS)
   a. MSS SP-69 Pipe Hangers and Supports – Selection and Applications

1.03 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:


1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Field quality-control inspection and test reports.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of an Independent Testing Laboratory.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS


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.

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:
      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.

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

PART 3 - EXECUTION

3.01 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 be any of the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   2. Copper DWV tube, copper drainage fittings, and soldered joints.

D. Aboveground, soil, waste, and vent piping NPS 5 and larger shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
2. Copper DWV tube, copper drainage fittings, and soldered 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; heavy-duty shielded, stainless-steel couplings; and hubless-coupling 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; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

3.02 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Section 22 13 16, Sanitary Waste and Vent Piping.

B. Basic piping installation requirements are specified in Section 22 05 00, Common Work Results for Plumbing.

C. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

D. 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 Section 22 05 00, Common Work Results for Plumbing.

E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

F. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

G. 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.

H. 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.

I. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
J. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.03 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 22 05 00, Common Work Results for Plumbing.
   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.

3.04 VALVE INSTALLATION

A. General-duty valves are specified in Section 22 05 23, 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 Section 22 13 19, Sanitary Waste Piping Specialties.

3.05 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment.
B. Pipe hangers and supports are specified in Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment:

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 Section 22 05 29, 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 one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.

2. NPS 3: 60 inches with 1/2-inch rod.

3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

4. NPS 6: 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. Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

3.06 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 Section 22 13 19, 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 Section 22 13 19, 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.

3.07 FIELD QUALITY CONTROL

A. During installation, notify Resident Engineer at least 24 hours before inspection must be made. Perform tests specified below in presence of Resident Engineer and the Seattle Public Utility authority.
   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 Resident Engineer and the Seattle Public Utility authority to observe tests specified below and to ensure compliance with requirements.
   3. Installation Verification: Section 22 08 00, Commissioning of Plumbing
B. Reinspection: If Resident Engineer and the Seattle Public Utility authority 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 Resident Engineer and the Seattle Public Utility authority.

D. Test sanitary drainage and vent piping according to manufacturers’ procedures of Resident Engineer and the Seattle Public Utility authority.

1. Test installed drainage lines and equipment according to Section 22 08 00, Commissioning of Plumbing:

   a. Provide and dispose of water required for testing. Refer to Section 01 57 24, Temporary Site Water Discharge, for testing water disposal requirements.

2. Prepare reports for tests and required corrective action.

3.08 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.

3.09 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit’s maintenance personnel to adjust, operate, and maintain Sanitary Waste and Vent Piping systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specification for the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Roof flashing assemblies.
   5. Flashing materials.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 07 62 00, Sheet Metal Flashing and Trim
   2. Section 22 05 00, Common Work Results for Fire Suppression
   3. Section 22 05 50, Mechanical Identification
   4. Section 22 08 00, Commissioning of Plumbing

1.02 REFERENCES

A. This Section incorporates by reference the latest revision of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. ASME A112.1.2 Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
      b. ASME A112.6.3 Floor and Trench Drains
      c. ASME A112.14.1 Backwater Valves
      d. ASME A112.14.3 Grease Interceptors
      e. ASME A112.36.2M Cleanouts
      a. ASTM A74 Standard Specification for Cast Iron Soil Pipe and Fittings
b. ASTM B32 Standard Specification for Solder Metal

c. ASTM C564 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

3. American Society of Sanitary Engineering (ASSE)
   a. ASSE 1072 Floor Drain Trap Seal Protection Devices.

1.03 SUBMITTALS
   A. Procedures: Section 01 33 00, Submittal Procedures.
   B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.04 QUALITY ASSURANCE
   A. Drainage piping specialties shall bear label, stamp, or other markings of an Independent Testing Laboratory.

PART 2 - PRODUCTS

2.01 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:
         c. Tyler Pipe; Wade Div.
         d. Zurn Plumbing Products Group; Specification Drainage Operation.
      2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
      3. Size: Same as connected drainage piping
      5. Closure: Countersunk or raised-head, cast-iron plug.
      6. 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:
c. Tyler Pipe; Wade Div.
d. Zurn Plumbing Products Group; Light Commercial Operation.
e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule heavy-duty, adjustable housing cleanout.

3. Size: Same as connected branch.

4. Type: Cast-iron soil pipe with cast-iron ferrule Heavy-duty, adjustable housing.

5. Body or Ferrule: Cast iron.


7. Outlet Connection: Spigot.

8. Closure: Cast-iron plug.

9. Adjustable Housing Material: Cast iron with threads.


11. Frame and Cover Shape: Square.

12. Top Loading Classification: Extra Heavy Duty.

13. 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:

   c. Tyler Pipe; Wade Div.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.

3. Size: Same as connected drainage piping.


5. Closure: Countersunk or raised-head, cast-iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.


2.02 FLOOR DRAINS

A. Cast-Iron Floor Drains: FD-1, FD-2

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:
   b. Prier Products, Inc.
   e. Tyler Pipe; Wade Div.
   f. Zurn Plumbing Products Group; Light Commercial Operation.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3 with backwater valve.

3. Pattern: Area drain heel proof.


5. Seepage Flange: Required.

6. Anchor Flange: Required.

7. Clamping Device: Required.

8. Outlet: Bottom.


12. Top or Strainer Material: Gray iron.


14. Top Shape: Square.

15. Dimensions of Top or Strainer: Scheduled.


17. Funnel: Required if scheduled.
18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.


21. Trap Features: Cleanout and trap-seal primer valve drain connection.

B. Cast-Iron Floor Drains: FD-3

1. Available Manufacturers:
   a. Pro Set Systems

2. Standard:
   a. ASME A112.6.3 with backwater valve.
   b. ASSE 1072

3. Pattern: Area drain heel proof.


5. Seepage Flange: Required.

6. Anchor Flange: Required.

7. Clamping Device: Required.

8. Outlet: Bottom.


12. Top or Strainer Material: Gray iron.


14. Top Shape: Square.

15. Dimensions of Top or Strainer: scheduled


17. Funnel: Required if scheduled.

18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.

19. Elastomeric, Normally closed trap guard device utilizing a normally closed seal to prevent evaporation of the trap seal and also protect against sewer gases from backing up into habitable areas. It opens with fluid and allows liquid drainage to flow through into the building drain.
a. Material: Smooth, soft, flexible, elastomeric PVC material molded into shape of duck’s bill, open on top with curl closure at bottom.

b. Allows wastewater to open and adequately discharge floor drain through its interior.

c. Closes and returns to original molded shape after wastewater discharge is complete.

d. The device shall conform to ASSE 1072

e. The product shall be installed in accordance with the manufactures installation instructions

f. The product shall only be installed in a floor drain complying with ANSI / ASME A112.6.3

C. Cast-Iron Floor Drains: FD-3

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:
   b. Prier Products, Inc.
   e. Tyler Pipe; Wade Div.
   f. Zurn Plumbing Products Group; Light Commercial Operation.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3 with backwater valve.

3. Pattern: Area drain heel proof.


5. Seepage Flange: Required.

6. Anchor Flange: Required.

7. Clamping Device: Required.

8. Outlet: Bottom.


12. Top or Strainer Material: Gray iron.
14. Top Shape: Square.
15. Dimensions of Top or Strainer: scheduled
17. Funnel: Required if scheduled.
18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
21. Trap Features: Cleanout and trap-seal primer valve drain connection.

D. Cast-Iron Floor Drains: FD-3
1. Available Manufacturers:
   a. Pro Set Systems
2. Standard:
   a. ASME A112.6.3 with backwater valve.
   b. ASSE 1072
3. Pattern: Area drain heel proof.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
12. Top or Strainer Material: Gray iron.
14. Top Shape: Square.
15. Dimensions of Top or Strainer: scheduled
17. Funnel: Required if scheduled.
18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.

19. Elastomeric, Normally closed trap guard device utilizing a normally closed seal to prevent evaporation of the trap seal and also protect against sewer gases from backing up into habitable areas. It opens with fluid and allows liquid drainage to flow through into the building drain.

   a. Material: Smooth, soft, flexible, elastomeric PVC material molded into shape of duck’s bill, open on top with curl closure at bottom.

   b. Allows wastewater to open and adequately discharge floor drain through its interior.

   c. Closes and returns to original molded shape after wastewater discharge is complete.

   d. The device shall conform to ASSE 1072

   e. The product shall be installed in accordance with the manufacturers installation instructions

   f. The product shall only be installed in a floor drain complying with ANSI / ASME A112.6.3

2.03 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:

      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 10 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.


2.04 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

   1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.

   2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.

2. Size: Same as connected waste piping.
   a. NPS 2: 4-inch- minimum water seal.
   b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.
   5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:
   1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
   2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:
   1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
   2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:
   1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
   2. Size: Same as connected stack vent or vent stack.

2.05 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.

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

3.01 INSTALLATION

A. Refer to Section 22 05 00, Common Work Results Plumbing.

B. For piping joining materials, joint construction, and basic installation requirements.

C. 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.

D. 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.

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

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

G. Install 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 and see architectural floor layouts for finishes.

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.

5. Install traps below structure where ever possible. In some cases the distance between floor and the bottom of structure is significant.

H. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

I. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

J. Assemble open drain fittings and install with top of hub 2 inches above floor.

K. Install deep-seal traps on floor drains and other waste outlets, if indicated.

L. 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.

M. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

N. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

O. Install vent caps on each vent pipe passing through roof.

P. 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.

Q. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
R. 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.

3.02 CONNECTIONS

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

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

3.03 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 Section 07 62 00, 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.

3.04 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 50, Mechanical Identification.

3.05 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.
3.06 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Sanitary Waste Piping Specialties systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
1.01 SUMMARY

A. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 08 00, Commissioning of Plumbing
2. Section 01 78 23, Operation and Maintenance Data
3. Section 22 14 10, Pumping Station Piping and Appurtenances

1.02 REFERENCES

A. This Section incorporates by reference the latest revision of the following documents.

1. American Society for Testing and Materials International (ASTM)
   b. ASTM A74 Standard Specification for Cast Iron Soil Pipe and Fittings
   c. ASTM D653 Standard Terminology Relating to Soil, Rock, and Contained Fluids
   d. ASTM D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

2. International Plumbing Code and local amendments

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Submit shop drawings showing piping layouts, sizes, types, valves, drains, and cleanouts.

C. Submit manufacturers' product data for specified materials and equipment.

1. Area Drains
2. Trench Drains

D. Submit equipment manufacturer's printed operating and maintenance instructions in accordance with Section 01 78 23, Operation and Maintenance Data, including detailed
parts list, recommended spare parts list, and complete operation and maintenance procedures.

E. Submit certified test results and certificates of compliance as necessary to verify conformance with specified requirements.

1.04 PROJECT CONDITIONS

A. Install drainage piping on surfaces and structures capable of supporting the piping. Prior to installation verify tunnel gradient and conditions provide positive flow through the track drainage piping to the low point pump station.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Pipe and Fittings

1. General: Provide pipe and fittings of sizes and configurations indicated. Provide cast iron ASTM A74 pipe and fittings for non-pressure piping.

2. Use Polyvinyl chloride (PVC), ASTM D1785, Schedule 80, Type I, Grade 1 for embedded track drainage piping.
   a. Fittings: Same material and schedule as pipe.

B. Drainage Inlets

1. General: Drainage inlets include a galvanized sheet pan, grate and frame as detailed on the Contract Drawings.

2. Sheet Metal Pan: 16 gauge sheet metal, galvanized to meet ASTM A653 G90.

3. Grate and Frame: Cast iron body, heavy-duty.

C. Gutter and Trench Drains

1. Provide gutter and trench drains manufactured of heavy cast iron with double drainage patterns, sediment bucket, integral seepage pan and trap primer connection. Provide heel proof strainer of chrome plated, cast brass, polished brass or buff polished nickel alloy, as indicated, attached to a brass threaded collar for adjustment to varying floor thicknesses. Provide cast iron, extra heavy traffic pattern gutter or trench drains, where indicated. All strainers shall be vandal proof.

D. Cast-Iron Area Drains: AD-1 AD-2

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:
   b. Prier Products, Inc.
d. Tyler Pipe; Wade Div.
e. Zurn Plumbing Products Group; Light Commercial Operation.
f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3.

3. Pattern: Area drain heel proof.


5. Seepage Flange: Required.

6. Anchor Flange: Required.

7. Clamping Device: Required.

8. Outlet: Bottom.


11. Top or Strainer Material: Stainless steel heel proof.


13. Top Shape: Square.

14. Dimensions of Top or Strainer: scheduled

15. Top Loading Classification: Extra Heavy-Duty.

16. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.

E. Cleanouts

1. Size and select cast iron cleanouts conforming to ASTM A48, Class 25B.

2. Install adjustable type floor cleanouts that have scoriated nickel alloy cover and membrane clamping device.

3. Select bolted, wedge type wall cleanouts which have a cover. Select a stainless steel cover plate that can be mounted in a flanged frame and secured to the plug with a vandal-proof screw.

4. Install exposed cleanouts with a raised brass head cleanout plug.

5. Install grade cleanouts with an adjustable sleeve housing, with a threaded brass plug and a countersunk slot.

F. Access Covers and Frames

G. Refer to Section 22 14 10, Pumping Station Piping and Appurtenances, for requirements.
PART 3 - EXECUTION

3.01 PREPARATION
A. Prior to installing or placing drainage products, insure excavations are free from water and extraneous material immediately therein.
B. Clean interior of pipe, pipe fittings, drains, and cleanouts before installation.
C. Install sleeves through walls, floors, roofs, and other structures before drainage lines are installed.

3.02 INSTALLATION
A. Install track drainage piping as detailed on the Contract Drawings.
B. Install cleanouts which are the same size as the pipe up to and including 4 inches, 6 inches and larger with 4 inches as a minimum. Cleanouts for drainage pipe include, a long-sweep 1/4 bend or one or two 1/8 bends extended to the place indicated. Use T-pattern, 90-degree branch drainage fittings with screw plugs for wall or accessible piping cleanouts.

3.03 FIELD QUALITY CONTROL
A. Testing
   1. Do not cover products to be embedded in concrete until inspections, testing, and acceptance of those products have occurred.
   2. Test installed storm drainage lines and equipment according to Section 22 08 00, Commissioning of Plumbing and as follows.
      a. Provide and dispose of water required for testing. Refer to Section 01 57 24, Temporary Site Water Discharge, for testing water disposal requirements.
   3. Installation Verification: Section 22 08 00, Commissioning of Plumbing.

3.04 CLEANING
A. Removing foreign material from the surfaces of products when cleaning. Leave the manufacturer's labels intact. Flush all sections of the piping system and dispose of the flushing water from the tunnel using temporary pumps where necessary.
B. It is the contractor's responsibility to apply for and secure all permits required by the City of Seattle and the Seattle Public Utility to drain into sewer or storm systems.

3.05 COMMISSIONING
A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Drainage System for Structures and equipment See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing the station drainage pumping piping and appurtenances indicated on the Contract Drawings and within this Contract Specification.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 08 00, Commissioning of Plumbing
2. Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment
3. Section 33 01 00, Operations and Maintenance of Utilities

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society of Mechanical Engineers (ANSI)
   a. ANSI A13.1 Scheme for Identification of Piping Systems
   b. ANSI B16.1 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125 and 250
   c. ANSI B18.5 Round Head Bolts (Inch Series)
   d. ANSI B18.10 Track Bolts and Nuts
   e. ANSI B18.22 Plain Washers
   f. ANSI B31.1 Power Piping and Process Piping SET
   g. ANSI B40.1 Gauges – Pressure Indicating Dial Type – Elastic Element

   b. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
   c. ASTM A58 Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
   d. ASTM A112 Moisture-Induced Stress Sensitivity for Plastic Surface Mount Devices

ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A164 ASTM Dictionary of Engineering Science and Technology

ASTM A536 Standard Specification for Ductile Iron Castings

ASTM B127 Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet and Strip

ASTM D2000 Standard Classification System for Rubber Products in Automotive Applications

3. US Federal Specifications (Fed. Spec.)
   a. Fed. Spec. FF-S-325 - Shield, Expansion; Nail Expansion, and Nail, Drive Screw (Devices, Anchoring, Masonry)
   c. Fed. Spec. WW-P-421 - Pipe, Cast Gray Ductile Iron, Pressure (for Water and Other

4. Hydraulic Institute Standards (HI)
   a. ANSI/HI 9.8 Centrifugal and Vertical Pump Intake Design
   b. ANSI/HI 11.6 Submersible Pump Tests

5. American Water Works Association (AWWA)
   a. AWWA C104 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings
   b. AWWA C110 Ductile-Iron and Gray-Iron Fittings for Water
   c. AWWA C111 Rubber gasket Joints for Ductile Iron Pressure Pipe & Fittings
   d. AWWA C115 Standard for Flanged Ductile-Iron Pipe With Threaded Flanges
   e. AWWA C150 Thickness Design of Ductile-Iron Pipe
   f. AWWA C151 American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water
   g. AWWA C153 Ductile-Iron Compact Fittings for Water Service
   h. AWWA C210 Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
   i. AWWA C600 Installation of Ductile-Iron Water Mains and Their Appurtenances
   j. AWWA C606 Grooved and Shouldered Joints
6. Manufacturers Standardization Society (MSS)
   a. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
   b. MSS SP-69 Pipe Hangers and Supports – Selection and Application

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Submit the following four weeks prior to starting construction of the initial lining for the concrete wet well at the low-point cross passage pump station:

1. Calculations for pipe support or manufacturers load capacity data.

2. Manufacturer's Data. Submit manufacturer's standard drawings or catalog cuts and certificates of conformance for the following items:
   a. Pipe and fittings
   b. Joints and couplings (including gaskets)
   c. Valves
   d. Gauges
   e. Wall sleeves
   f. Pipe to wall penetration closure
   g. Floor hatches (including hardware)
   h. Manufacturer's installation instructions.

3. Shop Drawings. Show complete and accurate information of:
   a. Dimensioned piping layout, complete with locations of all supports, presented in tabular format with a description of each support type, at a minimum scale of 3/8 inch equal to 1 foot.
   b. Tests. Perform all tests required by applicable referenced publications, whether specified in that publication to be mandatory or otherwise. For tests which are not specified in the referenced publication to be performed at definite intervals during manufacture, verify tests have been performed within three years of the date of submittal of certificates on the same type, class, grade, and size of material as is being provided for the project.

4. Manufacturer's operation and maintenance material and manuals, in accordance with Section 33 01 00, Operation and Maintenance of Utilities.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Promptly remove damaged products from the job site. Replace damaged products with undamaged products.
B. Load and unload all pipe, fittings, valves, and appurtenances by hoists or skidding. Do not drop products. Do not skid or roll products on or against other products. Use pad slings, hooks, and pipe tongs in such a manner to prevent damage to products.

C. Keep stored products safe from damage or deterioration. Keep the interior of pipe, fittings, valves, and appurtenances free from dirt or foreign matter. Drain and store valves in a manner that protects valves from damage by freezing. Store gaskets, plastic pipe and fittings, and other products, which deteriorate with sunlight in a cool location, out of direct sunlight. Do not allow gaskets to come in contact with petroleum products.

D. Store valves and appurtenances in accordance with manufacturer's recommendations.

E. Stack ductile iron, plastic, and steel pipe according to the requirements of the pipe manufacturer. Do not stack fittings, valves, or valve stands.

**PART 2 - PRODUCTS**

**2.01 PIPE AND FITTINGS**

A. Furnish all pipe, fittings, and appurtenances as indicated on Contract Drawings and specified in this Section. For all pipe, fittings, valves, and appurtenances use only new products.

B. Non-Buried Pipe:

1. Located within the pump station, inside the wet well and the cross passage.

2. Grade C ductile iron pipe conforming to AWWA C151, as modified by Fed. Spec. WW-P-421.

3. Minimum metal wall thickness of Class 53 for flanged or grooved wall pipe.

4. Coated with coal tar epoxy, minimum 20 mil thick on the exterior surface of the pipe.

5. Flanged pipe:
   a. AWWA C115.

6. Cement mortar lining conforming to AWWA C210 Type V cement.

C. Non-Buried Joints:

1. Mechanical grooved type joints or flange joints with screwed on ductile iron flanges where required for connection to flanged valves.

2. Flanges that meet the requirements of AWWA Standard C115.


4. Field made-up flanges will not be allowed.

D. Non Buried Fittings:

1. Designed and manufactured fittings for a minimum pressure rating of 250 pounds per square inch (psi).

2. Mechanical grooved ends.
3. Flange joints conforming to ANSI/AWWA C110.

4. Grooved type joints conforming to ANSI/AWWA C110, for center to end dimensions and AWWA C153 or ANSI 21.10/WWA A-110 for wall thickness.

5. Lining cement mortar conforming to AWWA C210 Type V cement.

6. Factory furnished exterior coating equal to that of the connecting pipe.

E. Buried Pipe and Fittings:

1. Used for the buried storm water pumped discharge piping system, including the inter-tie piping between tunnels.

2. made up of restrained push-on joint pipe and fittings utilizing ductile iron components
   a. Restrained joint pipe:
      1) Ductile Iron manufactured in accordance with the requirements of ANSI/AWWA C151/A21.51.
      2) Push–on joints in accordance with ANSI/AWWA C111/A21.11
      3) Nominal thickness conforming to ANSI/AWWA C150/21.50 for working pressures to 350 psi and laying conditions as indicated on Contract Drawings.
   b. Restrained joint fittings and the restraining components: Ductile iron in accordance with the applicable requirements of ANSI/AWWA C110/A21.10 or C153/A21.53 with the exception of design dimensions specific to each manufacturer’s product.
   c. Cement Mortar lining and seal coating for pipe and fittings:
      1) ANSI/AWWA C104/A21.4.
      2) Outside coated in accordance with AWWA C210 and as described in Article 2.01 F herein.
   d. Acceptable manufactures of restrained joint pipe and fittings:
      1) TR-FLEX pipe and fittings, as manufactured by US Pipe
      2) Lok-Ring as manufactured by American Ductile Iron Pipe
      3) Approved equal.

F. Pipe Coating:

1. Applied to the exterior surfaces of the pipe in accordance with AWWA C210:
   a. Surface preparation: Solvent Clean (SSPC-SP-1) followed by abrasive blast-cleaning to Near White Metal (SSPC-SP-10) with an anchor profile between 3 and 4 mils.
   b. Two uniform coats of coal tar epoxy conforming to AWWA C210: Applied to a total dry film thickness of 20 to 30 mils.
c. Drying time between coats: 12 hours minimum, 24 hours maximum at 70 degrees F. Inter-coat drying time is critical. Dry according to manufacturer's recommendations.

G. Fabricated Wall Pipe:
1. Ductile iron
2. Provided grooved end by plain end
3. Of lengths as indicated on the Contract Drawings, complete with intermediate flange fabricated from hot rolled steel
4. Of the same thickness class, exterior coating and interior lining as the connecting pipe.

H. Non-Buried Groove-Type Mechanical Couplings:
1. Coupled with grooved ends by engaging and holding these ends to form a watertight joint by means of a bolted, segmental clamp housing enclosing a sealing gasket.
2. Provide a rigid joint comparable to a flanged system.
3. Clamp housing:
   a. Consist of two or more parts
   b. Made of ductile iron conforming to ASTM A 536.
   c. Bolts and nuts for connecting clamp housing connections:
      1) Track bolts and nuts conforming to ANSI B18.10
      2) Roundhead, square neck type conforming to ANSI B18.5
      3) Hex nuts conforming to ANSI B18.22;
      4) Zinc plated to ASTM A 164.
   d. Bolt holes: of a shape to hold fast the necks of the bolts used
4. Gaskets:
   a. Molded nitrile synthetic rubber, flush seal type, conforming to ASTM D 2000
   b. Supplied by the coupling vendor.
   c. Shaped to effectively seal joint against leakage, when compressed.
5. Grooved ends of piping: In accordance with the published recommendations of the manufacturer of the coupling, as approved by the Resident Engineer.
6. Strength of coupling: Not less than that of the pipe.
7. Covered with factory applied, 3 mil thick, coal tar epoxy coating.

I. Groove-Type Mechanical Flange Adapters:
1. Used to join fittings with grooved ends to flanged pipe and fittings.

2. Engage groove in pipe or fitting and hold this end to the adjoining flange to form a rigid, watertight joint.

3. Clamp housing: Consisting of two or more parts made of malleable iron conforming to ASTM A 536.


5. Gasket: Nitrile and supplied by the flange adapter manufacturer.

6. Flange washer: Used between the flange adapter gasket and the flange or flange gasket if so stipulated by the adapter manufacturer.

7. Flange: Conform to ANSI B16.1: Class 125 drilling.

8. Coating of the flange adapters: Equal to the approved coating for the grooved couplings

J. Flange Joint Accessories:

1. Gaskets for flange joints:
   b. Full face
   c. 1/8-inch thickness neoprene.


2.02 VALVES

A. Furnish all isolation, check and drain valves, shown on the discharge side of the sump pumps, as indicated on the Contract Drawings and specified herein.

B. Gate Valves (GVLV):

1. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

2. Class 125, NRS, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, non-rising stem, and solid-wedge disc.

3. Furnished with flanged end connections.

4. Flanges: Faced and drilled to the ANSI 125/150 standard.

5. Hand Wheel: Cast Iron ASTM A 126 Class B.

6. CWP Rating: 200 psig (1380 kPa).


8. Packing and Gasket: Asbestos free.

C. Swing Check Valves (CVLV):
1. Cast iron in accordance with ASTM A-126 Class B, with a steel reinforced, Buna-N rubber lined flapper with bubble-tight seating.

2. Unrestricted flow area

3. 125 pound class rating and a 175 psi working pressure.

4. The inside of the valve:
   a. Rubber lined such that internally the valve has no exposed metal surfaces.

5. Have a positive non-slip backflow device, for the purpose of backflushing the pumps.

6. Have a phenolic primer red oxide exterior coating.

7. Swing check valve: APCO Model 120 or approved equal

D. Ball Valves (DVLV):

1. Two inches and smaller for drain service:
   a. Cast iron body, ASTM A 126, Class B
   b. Have threaded end connections.

2. Cast iron ASTM A 126 Class B or ductile iron ASTM A 536 ball.

3. Seats: Cast Monel, ASTM B 127 or BUNA-N rubber


5. Tested to the design working pressure (150 psi) with the ball in the closed position to determine tightness of the ball and seats.

E. Actuated Drain Valve (EVLV):

1. 2-way solenoid valve, pilot-operated, 3/4-inch NTP connection, 3/4-inch orifice size, brass body, PTFE seals and disc, stainless steel wetted parts, 300 PSI operating pressure, watertight enclosure, UL listed for general purpose valve, ASCO 8210 Series, G
   a. Power: 120 VAC, 48 VA holding, 240 VA inrush

2.03 HANGERS AND SUPPORTS

A. Conform to MSS SP-58, MSS SP-69, Fed. Spec. WW-H-171E, ANSI B31.1, as indicated on the Contract Drawings and as specified in Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment, unless indicated otherwise.

B. Provide all stainless steel materials in the Wet Well areas and stainless steel or hot dip galvanized pipe hangers and supports in the pump rooms.

2.04 PIPING APPURTENANCES

A. Gauges. ANSI B40.1, single style pressure gauge for water with 4.5-inch dial, brass or aluminum case, bronze tube, gauge cock and pressure snubber. Provide scale range suitable for the intended service.
B. Sleeves in masonry and concrete walls, floors, and grade beams.

1. Above Grade:
   a. ASTM A53 Schedule 40 or Standard Weight, hot-dip galvanized steel pipe sleeves or cast in place with smooth inside surfaces.
   b. Sealant: Provide the required separation between the adjacent Class, Div. 2 Group Area.

2. Below Grade (or one side in contact with dirt): Thermoplastic with integral seal ring.

C. Pipe to Wall and Pipe to Floor Penetration Closure:

1. Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   a. Links: Loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut.

2. After the seal assembly is positioned in the sleeve, tighten bolts to expand the rubber sealing elements and provide an absolutely watertight seal between the pipe and wall opening.

3. All steel parts: 316 stainless steel.

4. Manufacturer: Link Seal, Thunderline Corporation, or equal.

D. Miscellaneous Steel:

1. Pipe supports, hangers, anchors, sleeves, and associated steelwork:
   a. Hot dip galvanized in accordance with ASTM A 153, 2 ounces per square foot minimum.
   b. Configured as indicated on Contract Drawings.

E. Expansion Shields:

1. Fed. Spec. FF-S-325

2. Of group, type, class, and style best suited for the purpose

3. Recessed not less than 2 1/2 inches into concrete or masonry, unless indicated otherwise.

4. Do not use devices of Groups IV, V, VI, and VII in sizes greater than 1/2 inch unless indicated.

5. Stainless steel.

2.05 PIPING IDENTIFICATION:

A. Provide permanent flexible non-fading markers conforming to ANSI A13.1 in color, letter size and label size.

B. Permanent washable, chemical, and environmental resistant.
C. Provide non-metallic fasteners with each marker.

D. Label designation and coloring as indicated in Sound Transit Standards.

E. Indicate flow direction with arrows adjacent to labels.

F. Spacing no greater than 10 feet.

G. Piping Identification:
   1. Fluid: Storm water
   2. Background: Green
   3. Lettering: White

H. Manufacturer/Model: Seton No. STR or approved equal.

2.06 SUMP PIT APPURTENANCES

A. Aluminum Angle Frame Sump Access Hatch:
   1. Performance Requirements: Provide access door and frame assemblies manufactured as integral units ready for installation.
      a. Opening Size: The nominal hatch size and clear inside opening is indicated on the Contract Drawings.
      b. Fabricate to support 600 pounds per square foot minimum live load.
      c. The pump access hatches shall be designed to provide fall through protection in accordance with OSHA standard 1910.23 and controlled confine space entry in accordance with OSHA standard 1910.146.
      d. The track drainage pump hatches in Cross Passage 31 and Platform Level Pump Room N5-5P25 shall have a triple leaf configuration, allowing each leaf to operate independently. Frame shall be a one piece unit.
      e. The sanitary drainage pump hatch in the Platform Level Janitor Room N5-5P12 shall have a double leaf configuration, allowing each leaf to operate independently. Frame shall incorporate a dovetail groove in the seat of the frame to accept a 1/8-inch gasket and shall be a one piece unit.
   2. Fabricate to support 600 pounds per square foot minimum live load.
   3. Cover: Reinforced 1/4" type 5086 aluminum diamond plate with steel hold open arm that automatically locks cover in a 90-degree open position. A removable exterior turn/lift handle with spring loaded ball detent shall be provided to open the cover.
   4. Design of access hatch shall incorporate a triple leaf configuration, allowing each leaf to operate independently. Frame shall be a one piece unit.
   5. Frame: Extruded aluminum, with a continuous 1-1/2" anchor flange. Include additional supports at mid-points as determined by hatch manufacturer for hatch configuration indicated on drawings.
6. Hinges: Stainless steel with a 3/8” grade 316 stainless steel pin. Hinges shall be bolted to the angle frame and diamond plate, with grade 316 stainless steel bolts and ny-lock nuts.

7. Hardware: 316 stainless steel recessed Slamlock, with keyway protected by a threaded stainless steel plug. Plug shall be flush with the top of the 1/4 inch diamond plate. Slamlock shall be fastened with grade 316 stainless steel bolts and washers. Provide a separate recessed padlock clip with hinged access cover. Provide recessed lift handle flush with top of cover.

8. Safety Grate (Access Doors At Pump Locations Only): The grating shall be designed to withstand pedestrian (300 PSF) loading. The sump access hatch design shall assure the safety grate is in place before the cover can be closed. Each grate shall be hinging system and shall lock in the 90-degree position once opened. Grate shall be coated with OSHA type safety orange color two part epoxy paint.

B. Steel Angle Frame Catch Basin Access Cover:
   1. Curb Frame Material: 1/4-inch steel angle with strap anchors welded to exterior.
   2. Cover Material: Steel diamond plate with steel flush lifting handle that does not protrude above the cover.
   3. Finish: ASTM A123 hot dipped galvanized for frame and cover.

C. Access Ladder:
   1. Ladder Material: 6061-T6 Aluminum
   2. Ladder Design: Shop fabricated ladder shall comply with OSHA Standard 1910.27. Include supports for connection to concrete wall as indicated on the Contract Drawings.
   4. Safety Extensions: Dual retractable aluminum posts on each side of ladder rung. Posts shall extend 54-inches above top most ladder rung in raised position.
   5. Attachments: Anchor bolts as indicated on Contract Drawings. See Section 21 05 00, Common Work Results For Fire Suppression, for anchor bolt specification.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Piping
   1. Install in accordance with the general requirements for installation of pipelines and with the applicable requirements of ANSI/ASME B31.1 and AWWA C600 each as applicable, except as otherwise specified or indicated on the Contract Drawings. Installed piping on supports as indicated, provide additional supports as required by the applicable standards. Coat all flange bolts with anti-seize compound.

B. Pipe Laying and Jointing
1. Employ the Contractors Quality Control representative before and after installation to inspect pipe, fittings, valves, and accessories. Reject those found defective.

2. Clean pipe and fittings to free from fins and burrs. Before placing in position, clean pipe, fittings, valves, and accessories be maintained in a clean condition.

3. Provided equipment for lowering sections of pipe into position. Do not, under no circumstances, drop or dump pipe, fittings, valves, or any other water line material into the work area.

4. Cut pipe accurately to measurements established at the site and work into place without springing or forcing. Replace any pipe or fitting that does not allow sufficient space for installation of jointing material with one of acceptable dimensions.

5. Provide anchors and support as indicated.

6. Keep the wet well free of water until force main has been connected and pipe through floor closures have been completed.

7. Seal open ends of pipe temporarily with plastic or wood end caps or bulkheads.

8. Repair all erection damage to pipe lining in accordance with AWWA C104.

9. Repair buried pipe coatings and covering of field joints with a two-coat epoxy coating conforming to Steel Structures Painting Council Paint No. 16. Apply to a minimum dry film thickness of 20 mils.

10. Brush bare steel surface to remove all mill scale prior to the application of the protective coating. Follow manufacturer's instructions for surface preparation.

C. Flanged Joints

1. Tighten flanged joints and flanged adapter joints. Avoid undue strain on flanges, valves, fittings, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes. Do not use undersized bolts. Ensure adjoining flange faces are not out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. Replace all flanged pipe or fitting whose dimensions do not allow the making of a flanged joint as specified.

D. Grooved Pipe

1. Where grooved pipe is employed, perform as much grooving as possible in shop under controlled conditions. Make field grooves with equipment recommended by the manufacturer of the couplings. Install pipe with end separation between straight pipe lengths of that rated for flexible radius cut grooves to allow for expansion and contraction of piping systems.

E. Valves

1. Install valves in accordance with AWWA C600. Install all valves in locations indicated on Contract Drawings and in accordance with manufacturer's written instructions.

F. Hanger and Support
1. Support piping at points indicated on Contract Drawings with type of hanger indicated and elsewhere as required by Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment, and the referenced standards

2. Vertical Piping: Supported at floor and at not more than 10-foot intervals.

3. Horizontal Piping: Supported as indicated on Contract Drawings. Support the 3-inch diameter cast iron drain line and all other lines smaller than 3 inch in diameter at a maximum spacing of 7 feet. Support cast iron drain with one hanger close to joint on the barrel.

G. Pipe Sleeves

1. Provide pipe sleeves where piping passes through walls or ceilings.

2. Determine the required inside diameter of each individual wall opening or sleeve before ordering, fabricating or installing any pipe or sleeve. Size the inside diameter of each wall opening as recommended by the manufacturer to fit the pipe to wall sleeve closure, to assure a watertight joint. Sizing may be obtained through manufacturer’s catalog.

3. Secure sleeves in proper position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls or roofs. Install sleeves in locations indicated on Contract Drawings and in any location necessary to install piping.

H. Anchorage

1. Provide anchorage for fastening work securely in place. Set anchors in concrete as the work progresses and space as indicated on Contract Drawings. If anchors are needed, but not indicated on Contract Drawings, obtain approval for sizes, types, and spacing of anchors from the Resident Engineer prior to installation. Anchorage not otherwise specified or indicated includes slotted/embedded inserts, expansion shields, drop-in-anchors; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts and lag bolts. Provide inserts of suitable and approved types where required for support or anchorage of equipment and finish construction. Inserts: stainless steel unless indicated or specified otherwise. Slotted inserts: of types required to engage with anchors. Anchors and anchor bolts in walls: stainless steel with nuts of a heavy duty corrosion resistant alloy. Use stainless steel lock washers under all nuts.

I. Pipe to Wall Penetration Closure

1. Install pipe to wall penetration closure in accordance with manufacturer's written instructions. Bolt heads for wall closures must be inside the pump station, bolt heads for floor closures must be on the inside of the sump.

3.02 FIELD QUALITY CONTROL

A. Hydrostatic Test

1. Pressure Piping:
   a. Meet the requirements of AWWA Standard C600
   b. Tested no less than two days after piping is complete
c. Tested no less than five days after concrete thrust blocks have been placed

2. Ductile Iron Piping:
   a. Fit ends of piping being tested with test plugs, caps or blind flanges with a tap of adequate diameter to fill and pressurize the system with water.
   b. Test plugs or caps or blind flanges: Capable of withstanding an internal pressure of 100 psi.
   c. Remove all instruments or other items that may be damaged by the test pressure.
   d. Fill all piping with water and expel all air from the piping. Tap the piping at high points, if necessary, to release all air from the piping.
   e. Apply 30 psi for eight consecutive hours to allow the cement lining to absorb moisture. Add water as required to make up loss.
   f. Test piping at a static pressure of 70 psi over a period of not less than four consecutive hours.
   g. Considered the test successful when the pressure drop over the test period is five psi or less.
   h. Repair all leaks and repeat the test until the pressure drop over the test period is five pounds per square inch or less.
   i. Remove all test equipment and plug all test holes at completion of test. Replace plugs watertight.

3.03 COMMISSIONING
   A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Pumping Station Piping and Appurtenances systems and equipment See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the following storm drainage piping inside the building.
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 22 05 00, Common Work Results for Plumbing
   2. Section 22 05 29, Hanger and Supports for Plumbing Piping and Equipment.
   3. Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment
   4. Section 22 08 00, Commissioning of Plumbing
   5. Section 22 14 23, Storm Drainage Piping Specialties
   6. Section 33 40 00, Storm Drainage Utilities

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society for Testing and Materials International (ASTM)
   b. ASTM C564 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
   d. ASTM D2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
2. American Society of Mechanical Engineers (ASME)
   a. ASME B16.45 Cast Iron Fittings for Solvent Drainage Systems

3. Cast Iron Soil Pipe Institute (CISPI)

4. Manufacturers Standardization Society (MSS)
   a. MSS SP-69 Pipe Hangers and Supports – Selection and Application

1.03 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Field quality-control inspection and test reports.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of an Independent Testing Laboratory.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. 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. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
1. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns.

PART 3 - EXECUTION

3.01 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. Aboveground storm drainage piping NPS 6 and smaller shall be the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

C. Underground storm drainage piping NPS 6 and smaller shall be the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.02 PIPING INSTALLATION

A. Storm sewer and drainage piping outside the building are specified in Section 33 40 00, Storm Drainage Utilities.

B. Basic piping installation requirements are specified in Section 22 05 00, Common Work Results for Plumbing.

C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Section 22 14 23, Storm Drainage Piping Specialties.

D. 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 Section 22 05 00, Common Work Results for Plumbing.

E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

F. Make changes in direction for storm piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

G. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

H. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
   1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.
I. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

J. Install PVC storm drainage piping according to ASTM D 2665.

K. Install underground PVC storm drainage piping according to ASTM D 2321.

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

3.03 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 22 05 00, Common Work Results for Plumbing.

B. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.04 VALVE INSTALLATION

A. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.

2. Install backwater valves in accessible locations.

3. Backwater valve are specified in Section 22 14 23, Storm Drainage Piping Specialties.

3.05 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Section 22 05 48, Vibration and Seismic Controls for Plumbing Piping and Equipment.

B. Pipe hangers and supports are specified in Section 22 05 29, Hanger 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 Section 22 05 29, Hanger 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 one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 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 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 PVC piping every 48 inches.
N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

3.06 CONNECTIONS

A. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
B. Connect storm drainage piping to roof drains and storm drainage specialties.

3.07 FIELD QUALITY CONTROL

A. During installation, notify Resident Engineer and the Seattle Utility code authority at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
   2. Final Inspection: Arrange for final inspection by Resident Engineer and the Seattle Utility code authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
B. Reinspection: If Resident Engineer and the Seattle Utility code 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 Resident Engineer and the Seattle Utility code authorities having jurisdiction.
D. Test storm drainage piping according to procedures of Resident Engineer and the Seattle Utility code authorities having jurisdiction. Perform and document tests in accordance with Section 22 08 00, Commissioning of Plumbing.

3.08 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.

3.09 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit’s maintenance personnel to adjust, operate, and maintain Facility Storm Drainage Piping systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 22 14 23
STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the following storm drainage piping specialties:
   1. Backwater valves.
   2. Cleanouts.
   3. Roof drains.
   4. Miscellaneous storm drainage piping specialties.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 22 05 00, Common Work Results for Plumbing
   2. Section 22 08 00, Commissioning of Plumbing

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. ASME A112.14.1 Backwater Valves
      b. ASME A112.21.2M Roof Drains
      c. ASME A112.36.2M Cleanouts
      a. ASTM A74 Standard Specification for Cast-Iron Soil Pipe and Fittings
   3. Manufacturers Standardization Society for the Valve and Fittings Industry
      a. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
      b. MSS SP-69 Pipe Hangers and Supports – Selection and Applications
      c. MSS SP-89 Pipe Hangers and Supports – Fabrications and Installation Practices
      d. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports
1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each type of product indicated.

1.04 QUALITY ASSURANCE
A. Drainage piping specialties shall bear label, stamp, or other markings of an Independent Testing Laboratory.

PART 2 - PRODUCTS

2.01 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:
      b. MIFAB, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   3. Size: Same as connected piping.
   5. Cover: Cast iron with bolted or threaded access check valve.
   7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
   8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. 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:
2.02 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:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.

3. Size: Same as connected drainage piping.

4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.

5. Closure: Countersunk or raised-head, cast-iron plug.

6. 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:
   b. Oatey.
   c. Sioux Chief Manufacturing Company, 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.

2. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.

3. Size: Same as connected branch.

4. Type: Heavy-duty, adjustable housing.

5. Body or Ferrule: Cast iron.


7. Outlet Connection: Threaded.

8. Closure: Cast-iron plug.

9. Adjustable Housing Material: Cast iron with threads.


11. Frame and Cover Shape: Square.

12. Top Loading Classification: Extra Heavy-Duty.

13. 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:


   b. MIFAB, Inc.


   d. Tyler Pipe; Wade Div.

   e. Watts Drainage Products Inc.

   f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.

3. Size: Same as connected drainage piping.

4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, drilled-and-threaded cast-iron plug.

6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.


2.03 ROOF DRAINS

A. Cast-Iron Roof 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:
   b. Marathon Roofing Products.
   c. MIFAB, Inc.
   d. Portals Plus, Inc.
   e. Prier Products, Inc.
   g. Tyler Pipe; Wade Div.
   h. Watts Drainage Products Inc.
   i. Zurn Plumbing Products Group; Light Commercial Operation.
   j. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.2M.


5. Dimensions of Body: scheduled

6. Combination Flashing Ring and Gravel Stop: Required.


8. Outlet: Bottom.


11. Underdeck Clamp: Required.

2.04 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:

1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.

2. Size: Same as connected conductor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to Section 22 05 00, Common Work Results for Plumbing, for piping joining materials, joint construction, and basic installation requirements.

B. 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.

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

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

E. Install roof drains at low points of roof areas according to roof membrane manufacturer’s written installation instructions. Roof materials are specified in Division 07, Thermal and Moisture Protection.

1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.

2. Position roof drains for easy access and maintenance.

F. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

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

H. 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.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22, Plumbing, Sections. Contract Drawings indicate general arrangement of piping, fittings, and specialties.
3.03 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.

3.04 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.05 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit’s maintenance personnel to adjust, operate, and maintain Domestic Water Piping Specialties systems and equipment See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing track drainage pumps, sanitary sewerage pumps, and packaged wastewater submersible pumps, and motors at the following locations:

1. Sanitary sewerage pump station(s) at Brooklyn Station
2. Escalator pit sumps, low-point pit sumps where indicated on the drawings.

B. Track Drainage Pump Stations: Furnish and install submersible, non-clog type pumps and motors with appurtenances necessary to complete the work shown or specified herein. Obtain all pumps from one manufacturer. Pumps and pump equipment shall be warranted by manufacturer for a minimum of five years. Pump control panels are indicated on the Contract Drawings. In addition, ensure all components of the pumping units including pumps, motors, lifting chains, submersible power cable, guide rails, and discharge elbow are furnished by the same manufacturer. In addition, specific pump station requirements are provided below:

C. Sanitary Sewerage Pump Station: Furnish and install submersible, grinder type pumps and motors with appurtenances necessary to complete the work shown or specified herein. Obtain all pumps from one manufacturer. Pumps and pump equipment shall be warranted by manufacturer for a minimum of five years. Pump control panels are indicated on the Contract Drawings. Install level transmitter and float switches to junction box indicated on Contract Drawings. In addition, ensure all components of the pumping units including pumps, motors, lifting chains, submersible power cable, guide rails, and discharge elbow are furnished by the same supplier.

D. Elevator Pit Sumps, Escalator Pit Sumps, and Low-Point Pit Sumps: Furnish and install packaged submersible wastewater sump pumps, automatic float switch, with appurtenances necessary to complete the work shown or specified herein. Obtain all pumps and appurtenances from one manufacturer. Pump and pump equipment shall be warranted by manufacturer for a minimum of five years.

1. At elevator and escalator pit sumps, provide additional oil detection control system to detect floating oil and prevent pump operation.

E. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 08 00, Commissioning of Plumbing
2. Section 22 14 01, Drainage System for Structures
3. Section 25 60 00, Building Management System
4. Section 26 05 00, Common Work Results for Electrical
5. Section 26 05 25, Wire and Cable
6. Section 26 05 26, Grounding and Bonding for Electrical Systems
7. Section 26 05 33, Raceway and Boxes for Electrical Systems
8. Section 26 05 53, Identification for Electrical Systems
9. Section 26 08 00, Commissioning of Electrical Systems
10. Section 26 29 13, Enclosed Controllers
11. Section 33 01 00, Operations and Maintenance of Utilities

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society for Testing and Materials International (ASTM)
2. Insulated Cable Engineers Association (ICEA)
3. National Electric Code (NEC)
4. National Electrical Manufacturers Association (NEMA)
5. Hydraulic Institute Standards
   a. ANSI/HI 9.8 Centrifugal and Vertical Pump Intake Design
   b. ANSI/HI 11.6 Submersible Pump Tests
6. National Electrical Manufacturers Association (NEMA)
   a. NEMA B Application and Installation Guidelines for Nonmetallic-Sheathed Cables
7. Submersible Wastewater Pump Association
8. Underwriters Laboratories
   a. UL 778 Motor-Operated Water Pumps

1.03 DEFINITIONS

A. BMS: Building Management System
B. PLC: Programmable Logic Controller
C. FM: Factory Mutual
D. MCC: Motor Control Center
E. NB: Northbound
F. SB: Southbound

1.04 PUMP SEQUENCE OF OPERATION

A. Track Drainage Pump Station: Pump Control System Sequence of Operation:

1. During normal operations: Sump pumps shall be ready in the automatic mode to start automatically if the water level is sensed by the level sensor to be above the set point where pump needs to start and shut off when the water level goes below the set level where pump needs to stop.

2. Continuous sump level shall be sensed by a locally mounted level transducer.

3. When an initial increasing liquid level (programmable BMS set point) is sensed in the sump, the small sump pump shall start and run until the level drops below a separately programmed BMS set point.

4. If the level is sensed to increase above a second separately programmed set point, one of the two large pumps shall start and run until the level decreases below a programmed set point. The large pump selected for operation shall be alternated by the BMS with each operating cycle.

5. If the liquid level is sensed to rise above a third, separately programmable set point, the second large sump pump shall turn on and run until the level decreases to a programmed level set point.

6. Every third operating cycle, (detection of initial level), operate one of the larger pumps in lieu of the smaller pump, as described in Article 1.04.A.2 herein. Alternate operation of the larger pumps.

7. Actuated Drain Valve Operation: After an operating cycle and all pumps have shut off, and a subsequent five minute timed period (adjustable set point), the drain valve shall be energized open for a timed period. At the end of the timed period the drain valve shall close. When any pump starts at any time, the drain valve shall close. The initial timed period at each pump station shall be as follows:

   a. Pump Station: 5 minutes

8. A float switch assembly shall indicate a low-level cutoff level and a high level alarm signal. If the sump level falls to the low level cutoff point, all pumps shall be unconditionally shut off and a pump controller alarm output will result in a common alarm condition being annunciated at the Operations Control Center via the BMS.

9. If a pump fails to start as monitored by the motor current feedback the next pump in the operating sequence shall start and a common alarm shall be annunciated at the Operations Control Center.

10. The sump pump internal thermal switches and float leakage sensor (FLS) shall indicate and alarm signal. A thermal overload or seal leakage condition will result in a common alarm condition being annunciated at the Operations Control Center.

B. Sanitary Sewerage Pump Station(s): Pump Control System Sequence of Operation:
1. Pump sequence applies to pump stations at:

2. During normal operations: Sump pumps shall be ready in the automatic mode to start automatically if the water level is sensed by the level sensor to be above the set point where pump needs to start and shut off when the water level goes below the set level where pump needs to stop.

3. Continuous sump level shall be sensed by a locally mounted level transducer.

4. When an initial increasing liquid level (programmable BMS set point) is sensed in the sump, the first sump pump shall start and run until the level drops below a separately programmed BMS set point.

5. If the level is sensed to increase above a second separately programmed set point, the second pump shall start and run until the level decreases below a programmed set point. The first pump selected for operation shall be alternated by the BMS with each operating cycle.

6. Actuated Drain Valve Operation: After an operating cycle and all pumps have shut off, and a subsequent five minute timed period (adjustable set point), the drain valve shall be energized open for a timed period. At the end of the timed period the drain valve shall close. When any pump starts at any time, the drain valve shall close. The initial timed period at each pump station shall be as follows:

   a. Station Pump Station: 5 minutes

7. A float switch assembly shall indicate a low-level cutoff level and a high level alarm signal. If the sump level falls to the low level cutoff point, all pumps shall be unconditionally shut off.

8. The sump pump internal thermal switches and float leakage sensor (FLS) shall indicate and alarm signal. A thermal overload or seal leakage condition will result in a common alarm condition being annunciated at the Operations Control Center.

9. If a pump fails to start as monitored by the motor current feedback the next pump in the operating sequence shall start and a common alarm.

1.05 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Submit the following:

1. Certified copies of reports of factory tests specified in this Section and/or required by the referenced standards.

2. Shop drawings with performance data and physical characteristics.

3. Pump/Motor performance charts showing curves for torque, current, power factor, input/output KW and efficiency.

4. Manufacturer's installation instructions.

5. Manufacturer's operation and maintenance material and manuals, in accordance with Section 33 01 00, Operation and Maintenance of Utilities.
6. Provide technical details for control and power wiring of sufficient length for field installation inside the pump control enclosure. These wires come as pre-installed at pump motors and included in shipping package of the equipment specified in this Section.

1.06 PROJECT COORDINATION

A. See Section 01 31 13, Project Coordination and Section 22 05 00, Common Work Results for Plumbing, for requirements.

B. Temporary Pumps: Coordinate the work of this section with the temporary pumps required by Section 01 50 00, Temporary Facilities and Controls.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Promptly remove damaged products from the job site. Replace damaged products with undamaged products.

B. Thoroughly clean all equipment, components, and subassemblies of all water, sand, grit, weld splatter, grease, oil, and other foreign materials before preparation for shipment.

C. Protect all machined surfaces against physical damage and exposure to the elements during shipment, handling, storage, and installation.

D. Pack pumps to provide ample protection from damage during shipment, handling, and storage.
   1. Cap and seal all openings.
   2. Protect control and power wiring from insulation damage.

PART 2 - PRODUCTS

2.01 SUBMERSIBLE TRACK DRAINAGE PUMPS (N04-SP-01,02,03 N05-SP-01,02,AND, 03)

A. General Requirements:
   1. Mating cast iron discharge connection of size indicated.
   2. 30 feet of stainless steel lifting cable or chain as required. Employ a lifting system with a working strength of 50 percent greater than the pump unit weight.
   3. Capable of delivering the gallons per minute (gpm) at the static and total dynamic head (TDH) as scheduled on the Contract Drawings.
   4. Pumps shall have continuously rising head curve to shutoff.
   5. Meet the applicable requirements of the Hydraulic Institute Standards
   6. Provide the power/instrument cable in lengths suited to the individual installations, but in no case less than 40 feet long.
   7. Pumps shall be removable through an access hatch without entering the sump.

B. Pump Design:
1. Automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from a bracket at the access opening to the discharge connection.

2. Sealed to the discharge connection by means of a machined metal to metal watertight contact. Do not allow any portion of the pump to bear directly on the sump floor.

C. Pump Construction:

1. ASTM A48, class 35B, gray cast iron, with smooth surfaces devoid of blow holes and other irregularities

2. Exposed Nuts and Bolts: AISI type 304 stainless steel

3. Metal Surfaces Coming into Contact with Storm Water (other than stainless steel or brass): Factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.

4. The pump system including the pump, motor and power cable shall be approved for use in areas classified as hazardous locations in accordance with the NEC Class I, Div. 2, Group C and D service as determined and approved by a U.S. nationally recognized Independent Testing Laboratory (U.L., FM).

D. Cooling System:

1. Non-Clog Pumps: Have integral motor cooling system conforming to the following description: A motor cooling jacket encircles the stator housing, providing for dissipation of motor heat regardless of the type of pump installation. An impeller, integral to the cooling system and driven by the pump shaft, provides the necessary circulation of the cooling liquid through the jacket. The cooling liquid passes about the stator housing in the closed loop system in turbulent flow providing for heat transfer. The cooling system has one fill port and one drain port integral to the cooling jacket. The cooling system shall provide for continuous pump operation in liquid temperatures up to 104 degrees F.

E. Cable Entry Seal:

1. Of a design that precludes specific torque requirements while ensuring a watertight and submersible seal.

2. Consists of a single cylindrical elastomer grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable. This assembly design allows for easy changing of the cable using the same entry seal when necessary.

3. Cable entry junction chamber and motor: separated by a terminal board which isolates the interior of the motor from foreign material gaining access through the pump top.

4. Attached to a 40 foot minimum long cable sized according to NEC and ICEA standards and an outer cable jacket made of oil resistant chloroprene rubber.

5. Use of epoxies, silicones, or other secondary sealing systems is not acceptable.
F. Motor:

1. Induction type with a squirrel cage rotor, shell type design, housed in an air filled watertight chamber.

2. NEMA type B with Class H insulation.

3. Stator:
   a. With windings and leads that are insulated with moisture resistant Class H insulation rated for 356 degrees F.
   b. Insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95 percent.
   c. Heat-shrink fitted into the cast iron stator housing.
   d. Do not use bolts, pins or other fastening devices requiring penetration of the stator housing.

4. Designed for continuous duty handling storm water at 104 degrees F and capable of up to 15 evenly spaced starts per hour.

5. Preset thermal switches:
   a. Set to open at 260 degrees F.
   b. Embedded in the stator lead coils to monitor the temperature of each phase winding.
   c. Used in conjunction with and supplemental to external; motor overload protection.

6. Hermetically sealed junction chamber containing the terminal board from the motor by an elastomer O-ring seal.

7. Connection between the cable conductors and stator leads with threaded compression type; binding posts permanently affixed to the terminal board.

8. Designed and assembled by the same manufacturer as the pump.

9. Designed for continuous operation up to 104 degrees F ambient with a NEMA Class B maximum operating 176 degrees F temperature rise.

10. Combined service factor of 1.15 and a voltage tolerance of plus or minus 10 percent.

11. Suitable for installation in a Class 1, Division 2, and Group C and D classified area. Use associated cable suitable for installation in a Class 1, Division 1, and Group C and D classified area as well.

12. Nameplate motor horsepower: Non-overloading throughout the entire pump performance curve from shut-off to run-out.

13. Capable of continuous submergence under 65 foot depth of water.

G. Bearings:
1. Support rotating pump shaft on two bearings:
   a. Permanently grease lubricated

2. Upper bearing: Single roller type

3. Lower bearing: Two row angular contact type to compensate for axial thrust and radial forces.

H. Mechanical Seal:

1. On each pump: positively driven tandem mechanical shaft seal system including two seal sets, each having an independent spring:
   a. The lower, primary seal unit:
      1) Located between the pump and the lubricant chamber
      2) Contain one stationary and one positively driven rotating tungsten-carbide ring
   b. The upper, secondary seal unit:
      1) Located between the lubricant chamber and the motor housing
      2) Contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring.

2. All seal rings: made up of individual solid sintered rings.

3. Lubrication of the seals: From lubricant reservoir that hydrodynamically lubricates the lapped seal faces of the stationary and rotating tungsten carbide rings.

4. Seal interfaces: held in contact using its own spring system.

5. No seals which require maintenance or adjustment or depend on direction of rotation for sealing.

6. Spin-Out Protection:
   a. Designs in which seals and bearing housing are protected by seal wear protection.
   b. Helical design that expels abrasive particles from the area around the seal chamber.

7. Lubricant chamber to prevent overfilling and to provide for expansion. Locate drain and inspection plug to allow easy access from the outside. Do not design the seal system to rely upon the pumped media for lubrication.

I. Pump Shaft:

1. In the same unit as the motor shaft. Couplings are not acceptable. Use AISI type 431 stainless steel for the shaft.

J. Impeller:
1. Non-Clog Pumps:
   b. Leading edges:
      1) Mechanically self-cleaned automatically upon each rotation as they pass across a spiral groove located on the volute suction.
      2) Screw-shaped, hardened to Rc 45 and capable of handling solids, fibrous materials, heavy sludge and other matter normally found in transit tunnel wastewater.
   c. Inlet with a screw shaped to provide an inducing effect for the handling of up to 5 percent sludge and rag-laden wastewater.
   e. Locked to the shaft, held by an impeller bolt and coated with alkyd resin primer.

K. Volute:
   1. A48 Class 35B gray cast iron.
   2. Integral spiral shaped cast groove(s) at the suction.
   3. Effectively sealing against the multi-vane, semi-open impeller.
   4. Sharp spiral groove(s) which provide the shearing edge(s) across which each impeller vane leading edge crosses during its rotation in order to remain unobstructed.
   5. Adjustable clearance between the internal volute bottom and the impeller leading edges.

L. Protection:
   1. Thermal switches for each phase which are wired in series to open at 260 degrees F
   2. Float type leakage sensor (FLS) to detect water in the seal leakage chamber.
   3. Connect the thermal switches and FLS to a Control & Monitoring Unit provided by the pump manufacturer for mounting in the field inside the pump controller for input to BMS.

2.02 SUBMERSIBLE SEWAGE PUMPS (N05-SP-04, 05, AND 06)

A. Submersible, Quick-Disconnect Grinder Pumps: Factory-assembled and -tested, duplex, single-stage, centrifugal, end-suction, submersible, direct-connected grinder pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps and with SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook" for guide-rail supports. Pumps shall be removable through an access hatch without entering the sump.
B. The pump system including the pump, motor and power cable shall be approved for use in areas classified as hazardous locations in accordance with the NEC Class I, Div. 2, Group C and D service as determined and approved by a U.S. nationally recognized Independent Testing Laboratory (U.L., FM).

C. Casing: Cast iron, with open inlet, legs (or guide-rail supports) that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

D. Impeller: Bronze or stainless steel; statically and dynamically balanced, with stainless-steel cutter, grinder, or slicer assembly and capable of handling solids; overhung, single suction, and keyed and secured to shaft.

E. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings and double mechanical seals.

F. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   1. Motor Housing Fluid: Oil.

G. Guide-Rail Supports: Include the following for each sewage pump:
   1. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
   2. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
   3. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
   5. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.

H. Pump Discharge Piping; Refer to Section 22 14 10, Pumping Station Piping and Appurtenances.

I. Protection:
   1. Thermal switches for each phase which are wired in series to open at 260 degrees F.
   2. Float type leakage sensor (FLS) to detect water in the seal leakage chamber.
   3. Connect the thermal switches and FLS to a Control & Monitoring Unit provided by the pump manufacturer for mounting in the field inside the pump controller for input to BMS.
2.03 PACKAGED, SUBMERSIBLE WASTEWATER PUMP UNITS (N05-SP-07, 08, AND 09)

A. Factory-assembled and -tested, single-stage, centrifugal, end-suction, automatic-
operation, submersible effluent pump unit.

B. Pump Body and Impeller: Corrosion-resistant materials.

C. Pump Seals: Mechanical type.

D. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection. Comply
with requirements herein.

E. Power Cord: Three-conductor, waterproof cable of length required but not less than
72 inches (1830 mm) and with grounding plug and cable-sealing assembly for connection
at pump.

F. Pump Controls: Pump manufacturers simplex pump control panel, NEMA 4X enclosure,
circuit breaker, motor contactor, control transformer, level control flow switch and high
level float switch, run light, high level alarm light and horn with silence switch, one remote
monitoring contact.

G. Oil Detection Control System: Pump manufacturer’s controls to prevent pump operation
when lighter-than-water oils are detected. Include NEMA 4X enclosure, stainless steel
conductivity sensor probe, relays with sensitivity settings, alarm horn with alarm silencing
switch, one remote monitoring contact.

H. Include all manufacturer’s inter-connecting power cables, sensor cables, control cables,
probe cables, connecting plugs and receptacles. A minimum of 20 feet of cable shall be
provided from the pump to the control panel.

2.04 LEVEL TRANSMITTER:

A. Solid-state, microprocessor-based, head pressure sensing, utilizing a variable
capacity transducer element suitable for continuously submerged operation.

B. The submerged probes shall be approved for use in areas classified as hazardous
locations in accordance with the NEC Class I, Div. 2, Group C and D service as
determined and approved by a U.S. nationally recognized Independent Testing Laboratory
(U.L., FM).

C. Housing: Type 316 stainless steel

D. Sensors:

1. Rated for operation at negative 40 degrees F to 176 degrees F.

2. Loop powered

3. Provide a 0 to 50 mVdc output signal in response to a field adjustable input span
(0-30 pounds per square inch gage (psig) maximum).

E. Polyvinyl chloride jacketed cable long enough to reach BMS panel without any splices.

2.05 FLOAT SWITCHES:

A. High density polyethylene float body
B. Approximately 4.5 inches in diameter
C. Mercury-to-electrode type tilt switch rated at 4.5 Amperes at 120 VAC.
D. Float: Permanently marked to identify contacts as normally open or normally closed.
E. Manufacturer: Anchor Scientific Inc. Type S or approved equal.
F. Supply with heavy-duty No. 18/2 type SO cable with synthetic rubber or PVC jacket.
   1. Cable: Long enough to reach BMS panel or junction box in pump sump or pump room without any splices.

2.06 WIRING:
A. In accordance with Section 26 05 25, Wire and Cable, and all applicable codes.
B. Ground equipment and devices in accordance with manufacturer's recommendations to prevent ground loops.
C. Control Wiring:
   1. 24 V Circuits: Insulated copper 18 AWG minimum, rated for 300 VAC service.
   2. 120 VAC: 14 AWG minimum, rated for 600 VAC service.
      a. Cable: Long enough to reach track drainage pump control panel without any splices.

PART 3 - EXECUTION

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

3.02 INSTALLATION
A. Coordinate installation of sump pump motors and controls with the requirements of Section 26 05 00 Common Work Results for Electrical Systems, Section 26 05 25 Wire and Cable, Section 26 05 26 Grounding and Bonding for Electrical Systems, Section 26 05 33 Raceway and Boxes for Electrical Systems, Section 26 05 53 Identification for Electrical Systems, Section 26 08 00 Commissioning of Electrical Systems, Section 26 29 13, Enclosed Controllers.
B. Sump Pump Installation:
   1. As indicated and according to manufacturer's written instructions.
   2. Lubricate all moving parts as recommended by the manufacturer's written instructions.
   3. Anchor each pump securely with minimum embedment in solid concrete as indicated.
   4. Make all connections tight.
5. Pumping units: Level and plumb to ensure the units are uniformly supported.

6. Test for ease of pump movement on slide rails before permanently securing discharge flange in place.

7. Test for leakage at pump discharge flange

C. Nameplate: For each storm water pump, located where it can be easily read.

D. Cleaning: Clean grease, oil, or all other debris from the exterior surfaces of the pumps and motors.

E. Control Installation:
   1. Coordinate with Instrumentation and Electrical regarding purchase, installation and adjustment of controls.
   2. Bundle, train, and support wiring in enclosures.

F. Level Sensors:
   1. Install low-level alarm float switch, high-level alarm float switch and level transducer in accordance with manufacturer’s installation instructions for sanitary sewerage pump station at Brooklyn Station Room N5-5P12. Install wiring to junction box indicated on the Contract Drawings.
   2. Locate pressure transducer in sump in accordance with manufacturer’s installation instructions. Provide additional cable supports as required to located transducer.
   3. Adjust level transmitter and float switches to actuate at levels indicated.

G. Access Requirements: Coordinate with type and location of access hatches and lifting device to ensure that pumps can easily be removed and services.

H. Instruction: Arrange for manufacturer’s service representatives to provide instruction in maintenance and operation activities.

I. The gravity drainage system is not included in the scope of this section and is described in Contract Specification Section 22 14 01, Drainage System for Structures.

J. Provide temporary power to test pump installation at no additional cost to Sound Transit.

3.03 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26, Electrical, Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Section 26 05 26, Grounding and Bonding for Electrical Systems.

3.04 FIELD QUALITY CONTROL

A. Cleaning
   1. After installation, thoroughly clean the wet well of all solids, dirt and other debris
B. Pump Tests

1. See section 22 08 00 Commissioning of Plumbing for detailed test requirements.

2. Provide and dispose all water required for the testing. Refer to Section 01 57 24, Temporary Site Water Discharge for testing water disposal requirements.

3. Use testing instruments calibrated by a qualified Independent Testing Laboratory in accordance with Section 01 45 00, Quality Control.

4. Each pump in accordance with the manufacturer's written instructions and as specified in Section 22 14 01, Drainage System for Structures.

5. Field test each pump to establish field head and overall efficiency. Take voltage, power and amperage measurements for each test and include in the test report.

6. Run each pump individually for at least 20 minutes. Allow pumps to cycle through their normal operating sequence by operating them in automatic mode through the level control system. Provide all water required for testing at no additional cost to Sound Transit.

7. Record pressure with permanently installed gauges and flows with portable measuring equipment. Field test each pump, operating individually, by recording pressure and flow. The Flow rate may be measured by using portable measuring equipment or by noting the drop in the height of the water level in the sump during operation for a minimum period of time. The Resident Engineer will determine this minimum operation time period for calculating flow prior to the test. Record voltage, amps, power and power factor during all test modes of operation.

8. Trim pump impeller(s) to control flow rate if requested to do so by the Resident Engineer.

3.05 COMMISSIONING:

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Sump Pumps systems and equipment See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Commercial, storage electric water heaters.
   2. Water heater accessories.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 22 05 00, Common Work Results for Plumbing
   2. Section 22 08 00, Commissioning of Plumbing
   3. Section 22 05 19, Meters and Gages for Plumbing Piping
   4. Section 22 11 19, Domestic Water Piping Specialties
   5. Section 26 05 25, Wire and Cable
   6. Section 26 05 26, Grounding and Bounding for Electrical Systems

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

   1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASRAE)
      a. ASHRAE/ESNA 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings
      b. ASHRAE/ESNA 90.2 Energy-Efficient Design of Low-Rise Residential Buildings

   2. American Society of Mechanical Engineers (ASME)
      a. ASME B1.16.5 Pipe Flanges and Flanged Fittings
      b. ASME B1.16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500 and 2500
      c. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
      d. ASME PTC 25.3 Pressure Relief Devices

   3. American Society of Sanitary Engineers (ASSE)
a. ASSE 1003 Performance Requirements for Water Pressure Reducing Valves
b. ASSE 1005 Performance Requirements for Water Heater Drain Valves
c. ASSE 1010 Performance Requirements for Water Hammer Arresters

4. National Fire Protection Association (NFPA)

5. (NSF)
a. NSF 5 Water Heaters, Hot Water Supply Boilers and Heat Recovery Equipment
b. NSF 61 Drinking Water System Components – Health Effects

6. Underwriter Laboratories Inc. (UL)
a. UL 1453 Electric Booster and Commercial Storage Tank Water Heaters

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
C. Shop Drawings: Diagram power, signal, and control wiring.
D. Operation and maintenance data.
E. Warranty.

1.04 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to authorities having jurisdiction, and marked for intended use.
B. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
C. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.05 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
   a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period(s): From date of Substantial Completion:

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 Articles where titles below introduce lists, the following requirements apply to product selection:

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

2.02 COMMERCIAL ELECTRIC WATER HEATERS

A. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.

1. Available Manufacturers:
   b. Bock Water Heaters, Inc.
   d. Cemline Corporation.
   e. Electric Heater Company (The); Hubbell Heaters Division.
   f. GSW Water Heating Company.
   g. HESco Industries, Inc.
   h. Lochinvar Corporation.
   i. Precision Boilers.
   j. PVI Industries, LLC.
   k. RECO USA.
   n. Smith, A. O. Water Products Company.
   o. State Industries, Inc.
   a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
      1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   c. Insulation: Comply with ASHRAE/IESNA 90.1.
   d. Jacket: Steel with enameled finish.
   e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
      1) Staging: Input not exceeding 18 kW per step.
   f. Temperature Control: Adjustable thermostat.
   g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
   h. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.


2.03 WATER HEATER ACCESSORIES

A. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.
C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig-maximum outlet pressure, unless otherwise indicated.

E. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

PART 3 - EXECUTION

3.01 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.
   1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
   2. Concrete base construction requirements are specified in Section 22 05 00, Common Work Results for Plumbing.
   3. Supports and bracing shall comply with sections 22 05 29 and 22 05 48.

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial, water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Section 22 11 19, Domestic Water Piping Specialties for hose-end drain valves.

E. Install thermometer on outlet piping of water heaters. Refer to Section 22 05 19, Meters and Gages for Plumbing Piping for thermometers.

F. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

G. Fill water heaters with water.

3.02 CONNECTIONS

A. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

B. Ground equipment according to Section 26 05 26, Grounding and Bounding for Electrical Systems.

C. Connect wiring according to Section 26 05 25, Wire and Cable.

3.03 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:
1. **Leak Test:** After installation, test for leaks. Repair leaks and retest until no leaks exist.

2. **Operational Test:** After electrical circuitry has been energized, confirm proper operation.

3. **Test and adjust controls and safeties:** Replace damaged and malfunctioning controls and equipment.

   B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

### 3.04 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Electric Domestic Water Heaters systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

### 3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Sound Transit maintenance personnel to adjust, operate, and maintain commercial electric water heaters.

**END OF SECTION**
CONTRACT SPECIFICATIONS

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for the following:
   1. Faucets for lavatories and sinks.
   2. Flushometers.
   3. Toilet seats.
   4. Fixture supports.
   5. Water closets.
   7. Service sinks.
B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 07 92 00, Joint Sealants
   2. Section 22 05 00, Common Work Results for Plumbing
   3. Section 22 08 00, Commissioning of Plumbing
   4. Section 26 05 25, Wire and Cable
   5. Section 26 05 26, Grounding and Bonding for Electrical Systems

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. American National Standards Institute (ANSI)
      a. ANSI Z124.5 Standard for Plastic Toilet (Water Closet) Seats
   2. American Society of Mechanical Engineers (ASME)
      a. ASME A112.6.1M Supports for Off-the-Floor Plumbing Fixtures for Public Use
      b. ASME A112.18.1 Plumbing Supply Fittings
      c. ASME A112.18.2 2005 Plumbing Waste Fittings
d. ASME A112.18.3 Performance Requirements for Backflow Devices and Systems in Plumbing Fixture Fittings

e. ASME A112.19.2M Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals

f. ASME A112.19.3 Stainless Steel Plumbing Fixtures

g. ASME A112.19.5 Trim for Water-Closet Bowls, Tanks and Urinals

h. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
i. ASME B1.20.7 Hose Coupling Screw Threads (Inch)

3. American Society of Safety Engineers (ASSE)

a. ASSE 1001 Performance Requirements for Atmospheric Type Vacuum Breakers

b. ASSE 1011 Performance Requirements for Hose Connection Vacuum Breakers

c. ASSE 1025 Performance Requirements for Diverters for Plumbing Faucets with Hose Spray, Anti-Siphon Type, Residential Applications

4. International Code Council (ICC)

a. ICC A117.1 Standard for Accessible and Usable Buildings and Facilities

5. NSF

a. NSF 61 Drinking Water System Components – Health Effects

1.03 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.


1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

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

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Operation and maintenance data.

E. Manufacture’s Warranties

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to authorities having jurisdiction, and marked for intended use.


D. NSF Standard: Comply with NSF 61, "Drinking Water System Components—Health Effects," for fixture materials that will be in contact with potable water.

E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Vitreous-China Fixtures: ASME A112.19.2M.

G. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   5. Hose-Connection Vacuum Breakers: ASSE 1011.

H. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

I. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Grab Bars: ASTM F 446.
   3. Off-Floor Fixture Supports: ASME A112.6.1M.

PART 2 - PRODUCTS

2.01 LAVATORY FAUCETS

A. Lavatory Faucets, LV-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Contract Drawings or an approved equal product by one of the following:
   a. American Standard Companies, Inc.
   b. Bradley Corporation.
   c. Chicago Faucets.
   d. Delta Faucet Company.
   e. Eljer.
   f. Elkay Manufacturing Co.
   g. Fisher Manufacturing Co.
   h. Grohe America, Inc.
   i. Just Manufacturing Company.
   j. Kohler Co.
   k. Moen, Inc.
   m. Sayco; a Briggs Plumbing Products, Inc. Company.
   n. Speakman Company.
   o. T & S Brass and Bronze Works, Inc.
   p. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Single-control mixing valve. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 0.5 gpm.
d. Centers: 4 inches Adjustable.

e. Mounting: Deck, exposed.

f. Valve Handle(s): Lever.

g. Inlet(s): NPS 1/2 male shank.

h. Spout: Rigid type.

i. Spout Outlet: Aerator.


k. Drain: GRID

l. Tempering Device: Thermostatic Pressure balance.

2.02 MOP SINK FAUCETS

A. Mop Sink Faucets, MS-1:

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

a. American Standard Companies, Inc.

b. Bradley Corporation.

c. Broadway Collection.

d. Chicago Faucets.

e. Delta Faucet Company.

f. Dormont Manufacturing Company.

g. Eljer.

h. Elkay Manufacturing Co.

i. Fisher Manufacturing Co.

j. Grohe America, Inc.

k. Just Manufacturing Company.

l. Kohler Co.

m. Moen, Inc.


o. Sayco; a Briggs Plumbing Products, Inc. Company.

p. Speakman Company.

q. T & S Brass and Bronze Works, Inc.
2. Description: Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 2.5 gpm, unless otherwise indicated.
   d. Mixing Valve: Two-lever handle.
   e. Backflow Protection Device for Hose Outlet: Required.
   g. Centers: 8 inches Adjustable.
   h. Mounting: Back/wall, exposed.
   i. Handle(s): Lever.
   j. Inlet(s): NPS 1/2 male shank.
   k. Spout Type: Rigid, solid brass with wall brace Swing, solid brass.
   l. Spout Outlet: Aerator Hose thread.
   m. Vacuum Breaker: Required.
   o. Drain: Stopper with chain.

2.03 COUNTER MOUNTED SINK FAUCETS

A. Counter Mounted Sink Faucets, SK-1:

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

      a. American Standard Companies, Inc.
      b. Bradley Corporation.
      c. Chicago Faucets.
      d. Delta Faucet Company.
      e. Eljer, Inc.
      f. Elkay Manufacturing Co.
      g. Fisher Manufacturing Co.
h. GROHE America, Inc.

i. Just Manufacturing Company.

j. Kohler Co.

k. Moen, Inc.

l. Speakman Company.

m. T & S Brass and Bronze Works, Inc.

n. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Sink faucets for counter mounted sinks, ASME A112.18.1, including hot- and cold water indicators; coordinate faucet inlets with supplies and fixtures holes; coordinate outlet with spout and fixture receptor; polished chrome plate, 2.5 gallons per minute maximum flow rate, deck mounted single lever mixing valve, rigid solid brass spout with aerator outlet.

2.04 FLUSHOMETERS

A. Flushometers, WC-1:

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

a. Coyne & Delany Co.

b. Delta Faucet Company.

c. Sloan Valve Company.

d. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Flushometer for water-closet-type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.

a. Internal Design: Diaphragm operation.

b. Style: Exposed.

c. Inlet Size: NPS 1.

d. Trip Mechanism: Oscillating, lever-handle actuator.

e. Consumption: UR 1.0 gal./flush WC 1.6 gal./flush.

f. Tailpiece Size: NPS 1-1/4 and standard length to top of bowl.

2.05 TOILET SEATS

A. Toilet Seats, WC-1:
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:
   
   b. Centoco Manufacturing Corp.
   c. Church Seats.
   d. Kohler Co.
   e. Olsonite Corp.
   f. Pressalit A/S.
   g. Sanderson Plumbing Products, Inc.; Beneke Div.
   h. Sperzel.

2. Description: Toilet seat for water-closet-type fixture.
   
   a. Material: Molded, solid plastic with antimicrobial agent.
   b. Configuration: Open front without cover.
   c. Size: Elongated.
   d. Hinge Type: SS, self-sustaining.
   e. Class: Heavy-duty commercial.

2.06 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers;

   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   
   a. Engineered Brass Co.
   b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
   c. McGuire Manufacturing Co., Inc.
   d. Plumberex Specialty Products Inc.
   e. TCI Products.
   f. TRUEBRO, Inc.
   g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.
2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

2.07 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

B. Water-Closet Supports, WC-1:

1. Description: Combination carrier designed for accessible mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Lavatory Supports, LV-1:

1. Description: Type I, lavatory carrier with exposed arms and tie rods for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
3. With feet.

2.08 WATER CLOSETS

A. Water Closets, WC-1:

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. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Contract Drawings or an approved equal product by one of the following:

a. American Standard Companies, Inc.
b. Briggs Plumbing Products, Inc.
c. Capizzi.
d. Crane Plumbing, L.L.C./Fiat Products.

e. Eljer.

f. Kohler Co.

g. Mansfield Plumbing Products, Inc.

h. Peerless Pottery, Inc.

i. Sanitarios Azteca, S.A. de C.V.

j. St. Thomas Creations.

k. TOTO USA, Inc.

3. Description: Accessible, floor Floor-mounting, floor-outlet, vitreous-china fixture designed for flushometer valve operation.


a. Bowl Type: Elongated with siphon-vortex design. Include bolt caps matching fixture.

b. Height: Accessible.

c. Design Consumption: 1.6 gal./flush.


5. Flushometer: WC-1

6. Toilet Seat: WC-1

2.09 LAVATORIES

A. Lavatories, LV-1:

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

a. American Standard Companies, Inc.

b. Barclay Products, Ltd.

c. Briggs Plumbing Products, Inc.

d. Crane Plumbing, L.L.C./Fiat Products.

e. Eljer.

f. Gerber Plumbing Fixtures LLC.

g. Kohler Co.

h. Mansfield Plumbing Products, Inc.

i. Peerless Pottery, Inc.
j. Sterling Plumbing Group, Inc.
k. St. Thomas Creations.
i. TOTO USA, Inc.

2. Description: Accessible, wall-mounting, Stainless steel brushed finish.
   a. Type: Shelf back.
   b. Size: 19 by 16 inches rectangular.
   c. Faucet Hole Punching: Three holes, 4-inch centers.
   d. Faucet Hole Location: Top.
   e. Faucet: see Lavatory Faucets Article.
   g. Drain: Grid type with NPS 1-1/2 offset tailpiece
   h. Location: Near back of bowl.
   i. Drain Piping: chrome-plated, cast-brass P-trap; NPS 1-1/2, 0.045-inch-thick tubular brass waste to wall; and wall escutcheon.
      1) Exception: Omit P-trap if hair interceptor is required.
   j. Protective Shielding Guard(s): LV-1
   k. Fixture Support: Lavatory LV-1

2.10 MOP SINKS

A. Mop Sinks, MS-1:
   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:
      b. Florestone Products Co., Inc.
      c. Florestone Products Co., Inc.
      d. Precast Terrazzo Enterprises, Inc.
      e. Acorn Engineering Company.
   2. One-piece precast terrazzo, 12” deep by 24” by 24” with stainless steel cap on all curbs; Fiat Model TSB-100 or equal.
   4. b. Size: 28 by 28 inches
   5. c. Height: 12 inches.
6. Rim Guard: On all top surfaces.

7. Faucet: See Mop

8. Drain: Grid type.

2.11 COUNTER MOUNTED SINK

A. Counter Mounted Sink, SK-1:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Eljer, Inc.
   b. Kohler Co.
   c. American Standard America.
   d. Gerber Plumbing Fixtures, LLC.
   e. Briggs Plumbing Products, Inc.

2. Sink: One bowl, counter mounted, stainless steel, ASME A112.19.3,

3. Bowl:
   a. Dimensions: 17"x13"
   b. Drain: Grid type with NPS 1-1/2 straight tailpiece with 3-1/2-inch crumb cup centered in bowl.
   c. Faucet: See Counter Mounted Sink Faucets Article.

2.12 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Lavatory and Counter Mounted Sink Supply Fittings:

1. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.

2. Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.
   a. Operation: Wheel handle.

2.13 WASTE FITTINGS

A. Standard: ASME A112.18.2.

B. Trap: Same size as fixture drain outlet, chrome-plated two-piece, cast-brass trap and swivel elbow with 0.032-inch thick brass tube to wall; and chrome-plated-brass or steel wall flange.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install fixtures level and plumb according to roughing-in drawings.

G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

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

I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

J. Install flushometer valves for accessible water closets with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

K. Install toilet seats on water closets.

L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

N. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install shower flow-control fittings with specified maximum flow rates in shower arms.

P. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
Q. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Section 22 05 00, Common Work Results for Plumbing.

R. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Section 07 92 00, Joint Sealants.

3.02 CONNECTIONS
A. Piping installation requirements are specified in other Division 22, Plumbing, Sections. Contract Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
C. Ground equipment according to Section 26 05 26, Grounding and Bonding for Electrical Systems.
D. Connect wiring according to Section 26 05 25, Wire and Cable.

3.03 FIELD QUALITY CONTROL
A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.04 PROTECTION
A. Provide protective covering for installed fixtures and fittings.
B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Sound Transit.

3.05 COMMISSIONING
A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Plumbing Fixtures systems and equipment. See Section 22 08 00 Commissioning of Plumbing for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
   
   A. This Section includes specification for the following:
      
      1. Piping materials and installation instructions common to most piping systems.
      2. Dielectric fittings.
      3. Mechanical sleeve seals.
      4. Sleeves.
      5. Escutcheons.
      7. Equipment installation requirements common to equipment sections.
      8. Concrete bases.

   B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
      
      1. Section 23 08 00, Commissioning of HVAC Systems
      2. Section 03 05 15, Portland Cement Concrete
      3. Section 03 62 00, Non-Shrink Grouting
      4. Section 05 50 00, Metal Fabrications
      5. Section 07 84 00, Fire stopping

1.02 DEFINITIONS

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

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

   C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

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

1.03 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society of Mechanical Engineers (ASME)
   a. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
   b. ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
   c. ASME B31 Standards of Pressure Piping

   a. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   b. ASTM B32 Standard Specification for Solder Metal
   c. ASTM B813 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
   d. ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
   e. ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
   f. ASTM D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
   h. ASTM D2657 Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
   i. ASTM D2672 Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
   k. ASTM D2855 Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
   m. ASTM D3212 Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
n. ASTM F402 Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings


3. American Welding Society (AWS)
   a. AWS A5.8 Specification for Filler Metals for Brazing and Braze Welding
   b. AWS D1.1 Errata for Structural Welding Code - Steel

   B. AWS D10.12 Guide for Welding Mild Steel Pipe

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Welding certificates.

1.05 QUALITY ASSURANCE

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

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

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

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

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

PART 2 - PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23, Heating, Ventilation, and Air Conditioning (HVAC), Sections for pipe, tube, and fitting materials and joining methods.

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

2.02 JOINING MATERIALS

A. Refer to individual Division 23, Heating, Ventilation, and Air Conditioning (HVAC), 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.


G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.03 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 degrees 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 degrees 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 degrees F.

2.04 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: Stainless steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

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

### 2.06 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.

### 2.07 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

#### 3.01 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23, Heating, Ventilation, and Air Conditioning (HVAC), Sections specifying piping systems.

B. **Contract Drawings, 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 Section 07 84 00, Firestopping, for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Contract Specifications for roughing-in requirements.
3.02 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23, Heating, Ventilation, and Air Conditioning (HVAC), 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.


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 Article 1.04, herein.

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. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   3. 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.
   4. PVC Nonpressure Piping: Join according to ASTM D 2855.

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.

### 3.03 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.

### 3.04 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 HVAC 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.

### 3.05 CONCRETE BASES

A. **Concrete Bases:** Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic requirements of this 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 Section 03 05 15, Portland Cement Concrete.

3.06 ERECTION OF METAL SUPPORTS AND ANCHORAGES
   A. Refer to Section 05 50 00, Metal Fabrications, for structural steel.
   B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
   C. Field Welding: Comply with AWS D1.1.

3.07 ERECTION OF WOOD SUPPORTS AND ANCHORAGES
   A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
   B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
   C. Attach to substrates as required to support applied loads.

3.08 GROUTING
   A. Mix and install grout as specified in Section 03 62 00, Non-Shrink Grouting, for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
   B. Clean surfaces that will come into contact with grout.
   C. Provide forms as required for placement of grout.
   D. Avoid air entrapment during placement of grout.
   E. Place grout, completely filling equipment bases.
   F. Place grout on concrete bases and provide smooth bearing surface for equipment.
   G. Place grout around anchors.
   H. Cure placed grout.

3.09 COMMISSIONING
   A. See Section 23 08 00, Commissioning of HVAC Systems for commissioning requirement pertaining to the work of this Section.

END OF SECTION
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SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

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

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
1. National Electrical Manufacturers Association (NEMA)
   a. NEMA MG 1 Motors and Generators
2. Institute of Electrical and Electronics Engineers (IEEE)
   a. IEEE 841 Standard for the Petroleum and Chemical Industry-Severe Duty Totally Enclosed Fan Cooled (TEFC) Squirrel Cage Induction Motors-Up to and Including 500 hp

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

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.
C. Comply with IEEE 841 for severe-duty motors.
2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 140 degrees F and at altitude of 3300 feet above sea level.

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

2.03 POLYPHASE MOTORS

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

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. **Inverter-Duty Motors:** Class F temperature rise; Class H insulation.

4. **Thermal Protection:** Comply with NEMA MG 1 requirements for thermally protected motors.

C. **Severe-Duty Motors:** Comply with IEEE 841, with 1.15 minimum service factor.

### 2.05 SINGLE-PHASE MOTORS

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

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

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

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

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

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

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**
PART 1 - GENERAL

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.01 SLEEVES

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

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

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

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

2.02 STACK-SLEEVE FITTINGS

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

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

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

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

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

2.04 SLEEVE-SEAL FITTINGS

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

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

1. Presealed Systems.

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

2.05 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

3.01 SLEEVE INSTALLATION

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

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

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

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

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.

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

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

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

D. Install sleeves for pipes passing through interior partitions.

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

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

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00, Joint Sealants.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 00, Firestopping.

3.02 STACK-SLEEVE-FITTING INSTALLATION

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

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00, Sheet Metal Flashing and Trim.

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

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

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 00, Firestopping.

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.04 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves Stack-sleeve fittings.

5. Interior Partitions:

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 23 05 18

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.02 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

c. Insulated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

2. Escutcheons for Existing Piping:

a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.

b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.

f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.

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

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

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

2. Existing Piping: Split-casting, floor-plate type.

3.02 FIELD QUALITY CONTROL

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

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Brass ball valves.
3. Iron ball valves.
8. Bronze gate valves.
11. Iron globe valves.

B. Related Sections:

1. Section 23 05 53, Identification for HVAC Piping and Equipment, for valve tags and schedules.
2. Section 23 08 00, Commissioning of HVAC Systems.

1.02 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.
1.03 ACTION SUBMITTALS
A. Product Data: For each type of valve indicated.

1.04 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.

1.05 DELIVERY, STORAGE, AND HANDLING
A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.
B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES
A. Refer to HVAC valve schedule articles for applications of valves.
B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
C. Valve Sizes: Same as upstream piping unless otherwise indicated.
D. Valve Actuator Types:
1. **Handwheel**: For valves other than quarter-turn types.
2. **Handlever**: For quarter-turn valves NPS 6 and smaller except plug valves.
3. **Wrench**: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug-valve head.

A. **Valves in Insulated Piping**: With 2-inch stem extensions and the following features:

4. **Gate Valves**: With rising stem.
5. **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.
6. **Butterfly Valves**: With extended neck.

E. **Valve-End Connections**:

1. **Flanged**: With flanges according to ASME B16.1 for iron valves.
2. **Grooved**: With grooves according to AWWA C606.
3. **Threaded**: With threads according to ASME B1.20.1.

F. **Valve Bypass and Drain Connections**: MSS SP-45.

### 2.02 BRONZE ANGLE VALVES

A. **Class 150, Bronze Angle Valves with Bronze Disc**:

1. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.

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

### 2.03 BRASS BALL VALVES

A. **Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim**:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Jomar International, LTD.
   b. Kitz Corporation.
   c. Marwin Valve; a division of Richards Industries.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   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.

2.04 BRONZE BALL VALVES

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.

2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Three piece.
2.05 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Bray Controls; a division of Bray International.
   c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
   d. Crane Co.; Crane Valve Group; Flowseal.
   e. Crane Co.; Crane Valve Group; Stockham Division.
   f. DeZurik Water Controls.
   g. Hammond Valve.
   h. Jamesbury; a subsidiary of Metso Automation.
   i. Milwaukee Valve Company.
   j. NIBCO INC.
   k. Process Development & Control, Inc.
   l. Tyco Valves & Controls; a unit of Tyco Flow Control.
   m. Xomox Corporation.

2. Description:

   a. Standard: MSS SP-68.
   b. CWP Rating: 285 psig at 100 deg F.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: cast iron, ductile iron, or stainless steel.
   e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.

g. Disc: Carbon steel.

h. Service: Bidirectional.

2.06 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:

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

   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corporation.
   i. Zy-Tech Global Industries, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

2.07 IRON, CENTER-GUIDED CHECK VALVES

A. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. Val-Matic Valve & Manufacturing Corp.
2. Description:
   b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
   d. Style: Compact wafer.
   e. Seat: Bronze.

2.08 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Hammond Valve.
   b. Kitz Corporation.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Powell Valves.
   f. Red-White Valve Corporation.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.09 IRON GATE VALVES

A. Class 250, OS&Y, Iron Gate Valves:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Powell Valves.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

2.10 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Hammond Valve.
   c. Kitz Corporation.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Powell Valves.
   g. Red-White Valve Corporation.
   h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.11 IRON GLOBE VALVES

A. Class 250, Iron Globe Valves:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. 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. NIBCO INC.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 500 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.
PART 3 - EXECUTION

3.01 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.

3.02 VALVE INSTALLATION

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

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

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

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

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

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

3.03 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.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, gate, or plug valves.
   3. Throttling Service except Steam: Globe valves.
   4. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.

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

C. Select valves, except wafer types, with the following end connections:

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

3.05 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. Bronze Angle Valves: Class 150, bronze disc.
2. Ball Valves: Three piece, full port, brass or bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.
4. Bronze Gate Valves: Class 150, NRS.
5. Bronze Globe Valves: Class 150, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
3. High-Performance Butterfly Valves: Class 150, single flange.
4. Iron, Center-Guided Check Valves, NPS 2-1/2 to NPS 24: Class 150, metal seat.
5. Iron Gate Valves: Class 250, OS&Y.
3.06 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain General Duty Valves for HVAC Piping systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for the following:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Equipment supports.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. Boiler and Pressure Vessel Code (BPVC), Section IX, Welding and Brazing Qualifications
      b. ASME B31.3 Power Piping and Process Piping
      c. ASME B31.9 Building Services Piping
   2. Manufacturers Standardization Society (MSS)
      a. MSS SP-89 Pipe Hangers and Supports – Fabrication and Installation Practices
      b. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports
      c. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
      d. MSS SP-69 Pipe Hangers and Supports – Selection and Application
      a. ASTM C 533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
b. ASTM C 552 Standard Specification for Cellular Glass Thermal Insulation

c. ASTM A 36/A 36M Standard Specification for Carbon Structural Steel

d. ASTM C 1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

e. ASTM A 780 Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

4. Metal Framing Manufacturers Association (MFMA)
   a. MFMA 102 Guidelines for the use of Metal Framing

5. American Welding Society (AWS)
   a. AWS D1.1 Structural Welding Code

1.03 DEFINITIONS

A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.04 PERFORMANCE REQUIREMENTS

A. Design seismic supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment seismic supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from Resident Engineer and the Seattle Code authority having jurisdiction.

1.05 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Equipment supports.

C. Welding certificates.
1.06 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

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

2.02 STEEL PIPE SEISMIC HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3, Seismic Hanger and Support Applications, Article for where to use specific hanger and support types.

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Bergen-Power Pipe Supports.
4. Carpenter & Paterson, Inc.
5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co.
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.
2.03 TRAPEZE PIPE HANGERS

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

2.04 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:
   2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   3. GS Metals Corp.
   5. Thomas & Betts Corporation.
   6. Tolco Inc.
   7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.05 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Available Manufacturers:
   1. Carpenter & Paterson, Inc.
   2. ERICO/Michigan Hanger Co.
   3. PHS Industries, Inc.
   4. Pipe Shields, Inc.
   5. Rilco Manufacturing Company, Inc.
   6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

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

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.06 SEISMIC FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Available Manufacturers:
   a. Hilti, Inc.
   b. ITW Ramset/Red Head.
   c. Masterset Fastening Systems, Inc.
   d. MKT Fastening, LLC.
   e. Powers Fasteners.

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

1. Available Manufacturers:
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
   e. MKT Fastening, LLC.
   f. Powers Fasteners.

2.07 EQUIPMENT SUPPORTS

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

2.08 MISCELLANEOUS MATERIALS

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

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


2. Design Mix: 5000-psi, 28-day compressive strength.
PART 3 - EXECUTION

3.01 SEISMIC HANGER AND SUPPORT APPLICATIONS

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

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

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

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

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

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
   4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
   5. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
   6. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
   7. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
   8. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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

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

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

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

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

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

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

3.02 HANGER AND SUPPORT INSTALLATION

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

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

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

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

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

E. Fastener System Installation:

1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

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

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


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

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

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

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

3.03 EQUIPMENT SUPPORTS

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

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS

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

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

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

3.06 PAINTING

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

END OF SECTION
SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specification for the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Restraining braces and cables.

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Welding Society (AWS)
   a. AWS D1.1/D1.1M Errata for Structural Welding Code – Steel

2. American Association of State Highway and Transportation Officials (AASHTO)
   a. AASHTO M-251 Standard Specification for Plain and Laminated Elastomeric Bridge Bearings

   a. ASTM A 492 Standard Specification for Stainless Steel Rope Wire
   b. ASTM e 488 Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

4. Manufacturers Standardization Society (MSS)
1.03 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: As indicated on Contract Drawings.
   2. Building Classification Category: As indicated on Contract Drawings.
   3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC As indicated on Contract Drawings.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: As indicated on Contract Drawings for structural.
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second): Match Contract Drawings for structural.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each product indicated.
C. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
D. Welding certificates.
E. Qualification Data: For professional engineer.
F. Field quality-control test reports.

1.05 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
D. Restrained Mounts: All-directional mountings with seismic restraint.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
   1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
   2. Base: Factory drilled for bolting to structure.
   3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.
H. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.02 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an Independent Testing Laboratory acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

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

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

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

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

PART 3 - EXECUTION

3.01 APPLICATIONS

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

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

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

3.02 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Section 07 72 00, Roof Accessories, for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an Independent Testing Laboratory acceptable to authorities having jurisdiction providing required submittals for component.

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

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

E. Install seismic-restraint devices using methods approved by an Independent Testing Laboratory acceptable to authorities having jurisdiction providing required submittals for component.

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

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
H. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.03 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by an Independent Testing Laboratory acceptable to Resident Engineer and Seattle Code authorities having jurisdiction.
   2. Schedule test with Sound Transit through Resident Engineer, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   3. Obtain Resident Engineer's approval before transmitting test loads to structure. Provide temporary load-spreading members.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Resident Engineer.
   5. Test to 90 percent of rated proof load of device.
   7. Measure isolator deflection.
   8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
C. Remove and replace malfunctioning units and retest as specified above.
D. Prepare test and inspection reports.

3.05 ADJUSTING

A. Adjust isolators after piping system is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
C. Adjust active height of spring isolators.
D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION
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PART 1 - GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Mechanical Engineers (ASME)
      a. ASME A13.1 Scheme for Identification of Piping Systems

1.03 SUBMITTALS

A. Procedures: Section 01 33 00Submittal Procedures.
B. Product Data: For each type of product indicated.
C. Samples: For color, letter style, and graphic representation required for each identification material and device.
D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
E. Valve numbering scheme.
F. Valve Schedules: For each piping system to include in maintenance manuals.

1.04 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

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

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
C. Background Color: Red.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches high.

2.04 DUCT LABELS

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


C. Background Color: Black.

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

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

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


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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches high.

2.05 STENCILS

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


2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.
2.06 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

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

2.07 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting High-Performance Coatings."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer’s option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.
C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

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

D. Pipe Label Color Schedule:

1. Refrigerant Piping:
   a. Background Color: Black.

3.04 DUCT LABEL INSTALLATION

A. Install plastic-laminated self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.05 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

2. Valve-Tag Color:
   a. Refrigerant: Natural.

3. Letter Color:
   a. Refrigerant: Black.

3.06 WARNING-TAG INSTALLATION

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

END OF SECTION
SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for Testing, Adjusting, and Balancing (TAB) to produce design objectives for the following:
   1. Air Systems:
   2. Constant-volume air systems.
   3. HVAC equipment quantitative-performance settings.
   4. Verifying that automatic control devices are functioning properly.
   5. Reporting results of activities and procedures specified herein.
B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 23 08 00, Commissioning For HVAC System

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA)
      a. SMACNA HVAC Systems - Testing, Adjusting, and Balancing
      b. SMACNA HVAC Systems—Duct Design
   2. Air Movement and Control Association (AMCA)
      a. AMCA 201 Fans and Systems

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit six copies of TAB strategies and step-by-step procedures as specified in Article 3.02, herein. Include a complete set of report forms intended for use on this Project.
C. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm including the final report.
D. Warranties specified in this Section.
1.04 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB).

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.


1.05 PROJECT CONDITIONS

A. Full Sound Transit Occupancy: Sound Transit will occupy the site and existing building during entire TAB period. Cooperate with Sound Transit during TAB operations to minimize conflicts with Sound Transit's operations.

B. Partial Sound Transit Occupancy: Sound Transit may occupy completed areas of building before Substantial Completion. Cooperate with Sound Transit during TAB operations to minimize conflicts with Sound Transit's operations.

C. Coordination
   1. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls Installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
   2. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.06 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.
PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

   1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Section 01 78 39, Project Record Documents.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems—Duct Design," Sections 5 and 6 in this Contract Specification. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine system pumps to ensure absence of entrained air in the suction piping.

P. Examine equipment for installation and for properly operating safety interlocks and controls.

Q. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Sequence of operation for control modes is according to the Contract Documents.
   8. Controller set points are set at indicated values.
   9. Interlocked systems are operating.
   10. Changeover from heating to cooling mode occurs according to indicated values.

R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Automatic temperature-control systems are operational.
   3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.

5. Isolating and balancing valves are open and control valves are operational.

6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

7. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 FIELD QUALITY CONTROL

A. Tolerances

1. Set HVAC system airflow and water flow rates within the following tolerances:
   a. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
   b. Air Outlets and Inlets: 0 to minus 10 percent.
   c. Heating-Water Flow Rate: 0 to minus 10 percent.
   d. Cooling-Water Flow Rate: 0 to minus 5 percent.

B. General Procedures for Testing and Balancing

1. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and this Section.

2. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

3. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

C. General Procedures for Balancing Air Systems

1. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

2. Prepare schematic diagrams of systems' "as-built" duct layouts.

3. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

4. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

5. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
6. Verify that motor starters are equipped with properly sized thermal protection.
7. Check dampers for proper position to achieve desired airflow path.
8. Check for airflow blockages.
9. Check condensate drains for proper connections and functioning.
10. Check for proper sealing of air-handling unit components.
11. Check for proper sealing of air duct system.

D. Procedures for Constant-Volume Air Systems

1. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   a. Measure fan static pressures to determine actual static pressure as follows:
      1) Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
      2) Measure static pressure directly at the fan outlet or through the flexible connection.
      3) Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
      4) Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   b. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
      1) Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
   c. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
   d. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
   e. Obtain approval from Resident Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
   f. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors.
Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and all other operating modes to determine the maximum required brake horsepower.

2. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   a. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
      1) Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   b. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

3. Measure terminal outlets and inlets without making adjustments.
   a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

4. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
   a. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   b. Adjust patterns of adjustable outlets for proper distribution without drafts.

E. Procedures for Motors

1. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   a. Manufacturer, model, and serial numbers.
   b. Motor horsepower rating.
   c. Motor rpm.
   d. Efficiency rating.
   e. Nameplate and measured voltage, each phase.
   f. Nameplate and measured amperage, each phase.
   g. Starter thermal-protection-element rating.

2. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the
controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

F. Procedures for Condensing Units
1. Verify proper rotation of fans.
2. Measure entering- and leaving-air temperatures.
3. Record compressor data.

G. Procedures for Temperature Measurements
1. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
2. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
3. Measure outside-air, wet- and dry-bulb temperatures.

H. Temperature-Control Verification
1. Verify that controllers are calibrated and commissioned.
2. Check transmitter and controller locations and note conditions that would adversely affect control functions.
3. Record controller settings and note variances between set points and actual measurements.
4. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
5. Check free travel and proper operation of control devices such as damper and valve operators.
6. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
7. Check the interaction of electrically operated switch transducers.
8. Check the interaction of interlock and lockout systems.
9. Check main control supply-air pressure and observe compressor and dryer operations.
10. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
11. Note operation of electric actuators using spring return for proper fail-safe operations.

I. Additional Tests
1. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

2. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

3.04 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers’ test data.
   4. Field test reports prepared by system and equipment Installers.
   5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   3. Project name.
   4. Project location.
   5. Architect’s name and address.
   6. Engineer’s name and address.
   7. Contractor’s name and address.
   9. Signature of TAB firm who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents including the following:
       a. Indicated versus final performance.
b. Notable characteristics of systems.

c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Notes to explain why certain final data in the body of reports varies from indicated values.

14. Test conditions for fans and pump performance forms including the following:
   a. Settings for outside-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air systems. Present each system with single-line diagram and include the following:
   1. Quantities of outside, supply, return, and exhaust airflows.
   2. Duct, outlet, and inlet sizes.
   3. Pipe and valve sizes and locations.
   5. Position of balancing devices.

3.05 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Testing, Adjusting, and Balancing for HVAC systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes specifications for the following:
   1. Insulation Materials:
      a. Cellular glass.
      b. Mineral fiber.
   2. Fire-rated insulation systems.
   3. Insulating cements.
   4. Adhesives.
   5. Mastics.
   7. Factory-applied jackets.
   10. Tapes.
   11. Securements.
   12. Corner angles.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 07 84 00, Firestopping
   2. Section 22 07 00, Plumbing Insulation
   3. Section 23 31 13, Metal Ducts

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society for Testing and Materials International (ASTM)
b. ASTM B 209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
c. ASTM C 921 Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
d. ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials
e. ASTM C 871 Standard Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
f. ASTM C 795 Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
g. ASTM C 552 Standard Specification for Cellular Glass Thermal Insulation
h. ASTM C 450 Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
i. ASTM C 585 Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)
j. ASTM C 534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
k. ASTM C 553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for commercial and Industrial Applications
l. ASTM C 1290 Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
m. ASTM C 612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
n. ASTM C 547 Standard Specification for Mineral Fiber Pipe Insulation
o. ASTM C 1393 Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks
q. ASTM E 96 Standard Testing Methods for Water Vapor Transmission of Materials
r. ASTM D 1644 Standard Test Method for Nonvolatile Content of Varnishes
s. ASTM F 1249 Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor
1. ASTM C 1136 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

2. Military Specifications (MIL)
   a. MIL-A-24179A Adhesive, Flexible Unicellular Thermal Insulation
   b. MIL-A-3316C Adhesives, Fire-Resistant, Thermal Insulation
   c. MIL-C-19565C Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor Barrier

3. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

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

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

D. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per American Society for Testing and Materials ASTM E 84, by an Independent Testing Laboratory acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

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

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Comply with requirements of Part, Execution, herein, for locations where insulating materials shall be applied.

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

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

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

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in Article 2.07, herein.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Cell-U-Foam Corporation; Ultra-CUF.
   b. Pittsburgh Corning Corporation; Foamglas Super K.

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.

4. Board Insulation: ASTM C 552, Type IV.

5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.


7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Article 2.07, Factory Applied Jackets.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Duct Wrap.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; All-Service Duct Wrap.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Article 2.07, Factory Applied Jackets.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.

J. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000 Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.
   f. For operating temperatures higher than 850 degrees F, delete first subparagraph below and retain second subparagraph. ASJ requires field-applied adhesive and staples. ASJ with SSL does not require field-applied adhesive and staples, resulting in reduced installation labor.
2. Type I, 850 degrees F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Article 2.07, herein.

3. Type II, 1200 degrees F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Article 2.07, herein.

K. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Knauf Insulation; Permawick Pipe Insulation.
   b. Owens Corning; VaporWick Pipe Insulation.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 degrees F is 0.29 Btu x in./h x sq. ft. x degrees F or less. Factory-applied jacket requirements are specified in Article 2.07, herein.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.02 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a two-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
2.03 INSULATING CEMENTS

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Insulco, Division of MFS, Inc.; SmoothKote.
   c. Rock Wool Manufacturing Company; Delta One Shot.

2.04 ADHESIVES

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

B. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; CP-96.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Aeroflex USA Inc.; Aerosal.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; CP-82.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.


1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; CP-82.
   c. ITW TACC, Division of Illinois Tool Works; S-90/80.
   d. Marathon Industries, Inc.; 225.
   e. Mon-Eco Industries, Inc.; 22-25.

2.05 MASTICS

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

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; CP-35.
   b. Foster Products Corporation, H. B. Fuller Company; 30-90.
   c. ITW TACC, Division of Illinois Tool Works; CB-50.
   d. Marathon Industries, Inc.; 590.
   e. Mon-Eco Industries, Inc.; 55-40.
   f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 degrees F.


C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-76.
   b. Foster Products Corporation, H. B. Fuller Company; 30-45.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
   f. Vimasco Corporation; 750.

2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-70.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.

3. Materials shall be compatible with insulation materials, jackets, and substrates.

4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 degrees F.
6. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; CP-76-8.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.

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

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; CP-76.

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

2.07 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
2.08 FIELD-APPLIED FABRIC-REINFORCING MESH

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   b. Vimasco Corporation; Elastafab 894.

2.09 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; Metal Jacketing Systems.
   b. PABCO Metals Corporation; Surefit.
   c. RPR Products, Inc.; Insul-Mate.

2. Sheet and roll stock ready for shop or field sizing.

3. Finish and thickness are indicated in field-applied jacket schedules.


5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

6. Factory-Fabricated Fitting Covers:
   a. Same material, finish, and thickness as jacket.
   b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
   c. Tee covers.
   d. Flange and union covers.
   e. End caps.
   f. Beveled collars.
   g. Valve covers.
   h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
D. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Polyguard; Alumaguard 60.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
   b. Compac Corp.; 104 and 105.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.

3. Thickness: 11.5 mils.


5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   b. Compac Corp.; 110 and 111.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
   d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.

3. Thickness: 6.5 mils.


5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   
a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
b. Compac Corp.; 120.
c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.11 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   
a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   1) GEMCO; Nylon Hangers.
   2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
   2) GEMCO; Press and Peel.
   3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

d. Adhesive-backed base with a peel-off protective cover.
4. **Insulation-Retaining Washers:** Self-locking washers formed from 0.016-inch-thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. **Nonmetal Insulation-Retaining Washers:** Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) GEMCO.
      2) Midwest Fasteners, Inc.

C. **Staples:** Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. **Wire:** 0.080-inch nickel-copper alloy.

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

   b. Childers Products.
   c. PABCO Metals Corporation.
   d. RPR Products, Inc.

2.12 **CORNER ANGLES**

A. **PVC Corner Angles:** 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. **Aluminum Corner Angles:** 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.
PART 3 - EXECUTION

3.01 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements will be in contact with stainless-steel surfaces, use demineralized water.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
   4. For below ambient services, apply vapor-barrier mastic over staples.
   5. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   5. Handholes.
   6. Cleanouts.

3.03 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 07 84 00, Firestopping.

E. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Pipe: Install insulation continuously through floor penetrations.

3. Seal penetrations through fire-rated assemblies: Comply with requirements of Section 07 84 00, Firestopping.

3.04 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for percent coverage of tank and vessel surfaces.

2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.

d. Do not overcompress insulation during installation.

e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.

f. Impale insulation over anchor pins and attach speed washers.

g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.

2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from aluminum, at least 0.050 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.06 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.07 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.08 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end
of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.09 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 84 00, Firestopping.

3.11 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below.

B. Retain paint system in subparagraphs below for a flat, latex-emulsion size over insulation covering an exterior that is subject to normal use and moderate environments.

   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
C. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

D. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

E. Do not field paint aluminum or stainless-steel jackets.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Resident Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Resident Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in Article 3.13, Duct Insulation Schedule, General herein. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Resident Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in Article 3.16, Pipe Insulation Schedule, General, herein.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.13 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.

2. Indoor, exposed supply and outdoor air.

3. Indoor, concealed return located in nonconditioned space.

4. Indoor, exposed return located in nonconditioned space.

5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.

6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

7. Outdoor, concealed supply and return.

8. Outdoor, exposed supply and return.
B. Items Not Insulated:
1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
5. Flexible connectors.
7. Factory-insulated access panels and doors.

C. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

D. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

E. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

F. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

G. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

H. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

I. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

J. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 1.5-lb/cu. ft. nominal density.

3.14 EQUIPMENT INSULATION SCHEDULE
A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in Articles below that is not factory insulated.

3.15 PIPING INSULATION SCHEDULE, GENERAL
A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.16 INDOOR PIPING INSULATION SCHEDULE
A. Refrigerant Suction and Hot-Gas Piping: Flexible elastomeric, 1 inch thick.
B. Refrigerant Suction and Hot-Gas Flexible Tubing: Flexible elastomeric, 1 inch thick.

3.17 INDOOR, FIELD-APPLIED JACKET SCHEDULE
A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
B. If more than one material is listed, selection from materials listed is Contractor's option.
C. Ducts and Plenums, Concealed:
   1. None.
D. Ducts and Plenums, Exposed:
   1. Aluminum, Smooth 0.032 inch thick.
E. Equipment, Concealed:
   1. None.
F. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Corrugated: 0.032 inch thick.

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE
A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
B. If more than one material is listed, selection from materials listed is Contractor's option.
C. Ducts and Plenums, Concealed:
D. Piping, Concealed:
   1. Aluminum, Smooth: 0.032 inch thick.
E. Piping, Exposed:
1. Aluminum, Smooth: 0.032 inch thick.

3.19 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Commissioning process requirements for HVAC:
   1. Level 1 commissioning activities for HVAC
   2. Level 2 commissioning activities for HVAC
   3. Support for Level 3 commissioning activities related to HVAC
   4. Support for Level 4 commissioning activities related to HVAC

B. Related Sections:
   1. Section 01 91 13, General Commissioning Requirements for: General commissioning process requirements, including definitions, submittals, scheduling, execution of commissioning activities, and reporting.
   2. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC
   3. Section 23 09 00, Instrumentation and Control for HVAC
   4. Section 23 09 93, Sequence of Operations for HVAC Controls
   5. Section 23 21 13, Hydronic Piping
   6. Section 23 31 13, Metal Ducts
   7. Section 23 33 00, Air Duct Accessories
   8. Section 23 34 23, HVAC Power Ventilators
   9. Section 23 73 13, Modular Indoor Central Station Air Handling Units
   10. Section 23 74 14, Packaged Outdoor Wall Mounted Air Handling Units
   11. Section 23 81 23, Computer Room Air Conditioners
   12. Section 25 08 00, Commissioning of Integrated Automation
   13. Section 25 60 00, Building Management System
   14. Section 26 08 00, Commissioning of Electrical Systems

1.02 DEFINITIONS

A. Command: When used in the description of a commissioning activity, command means to use the station human machine interface (HMI) for the building management system (BMS) to control systems, equipment and components.
B. Systems, Equipment, and Components: Where these terms are used together or separately, they shall mean “as-built” systems, equipment, and components.

C. Human Machine Interface (HMI): Equipment, software, and functional programming at the locations shown on the Plans and as specified in Division 25 Section Building Management System.

1.03 SYSTEM DESCRIPTION

A. Commissioning work includes: Furnish labor and material to accomplish building commissioning as specified in Division 01 Section “General Commissioning Requirements” and herein, including:

1. Provide to the Commissioning Coordinator preliminary O&M information for use in developing commissioning test procedures.

2. Assist the Commissioning Coordinator in developing commissioning activity procedures and data forms submittals for work specified in this Section.

3. Provide information to the Commissioning Coordinator needed for control interface wiring diagrams submittals for the work of this Section.

4. Perform Level 1 commissioning activities specified in this Section, including installation verification, static tests, start-up, component tests, equipment tests, systems tests.

5. Perform Level 2 commissioning activities specified in this Section, including intra-station system interface tests.

6. Provide support for Level 3 commissioning activities, including jointly with the communications system contractor field testing points in the interface terminal strips, being present during level 3 testing with adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise. When material or equipment provided by this Division is found to be in conflict with specified criteria, adjust or replace said material or equipment, with the assistance of manufacturer as needed.

7. Provide support for Level 4 commissioning activities, including providing adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise during pre-revenue testing.

8. Operate equipment and system during commissioning activities as required by the Commissioning Coordinator.

9. Perform and document commissioning tests to verify readiness for commissioning test demonstration. Commissioning tests are specified herein.

10. Correct issues and repeat commissioning tests when results do not meet acceptance criteria.

11. Commissioning Test Demonstrations: General requirements for commissioning test demonstrations are specified in Division 01 Section 01 91 13, General Commissioning Requirements, Article 3.04, Level 1 and Level 2 Commissioning Activity Commissioning Test Demonstrations.
a. Repeat commissioning tests on a sample basis to demonstrate acceptable performance: Level 1 Component, Equipment, and System Commissioning Tests, and for Level 2 Intra-station system interface tests.

b. Record and submit commissioning test demonstration data and issues.

c. Correct issues and repeat commissioning test demonstration when results do not meet Acceptance Criteria.

12. Attend commissioning meetings as requested by the Commissioning Coordinator.

13. Report any inconsistencies or issues in system operations or performance.

14. Provide personnel to support commissioning test demonstration specified herein as requested by the Commissioning Coordinator.

15. In the event that a commissioning test demonstration fails, assist in determining the cause of failure. Make corrections as necessary.

16. Cooperate with Commissioning Coordinator to make equipment and systems ready for commissioning tests specified herein as early in the construction schedule as possible.

B. Cooperate with Commissioning Coordinator to accomplish commissioning work on schedule and in coordination with other trades.

1.04 DATA TREND LOGS

A. When required for specific tests under Part 3 herein, data trend logs shall comply with the following.

1. Format: Provide two hard copies of data graphs and one electronic copy of data graphs and data tabulations. Example data graphs and data tabulations similar to those required by this Article are included as attachments to this Section.

a. Data graphs format shall be annotated multiple data series graphs.

1) Where multiple data series are trend logged concurrently, present the data on a common horizontal time axis. Individual data series may be presented on a segmented vertical axis in order to avoid interference of one data series with another, and to accommodate different axis scale values.

2) Header: on each page: Contract number, equipment or system identification, commissioning test number, test date, sequential page number.

3) Annotate data graphs to identify the start time of each step of the test procedure in which a change to the system was manually initiated. Annotation shall include test procedure step number, minimum.

4) Annotate data graphs to identify each data plot with control point nomenclature and plaintext point name.
5) An example data graph is included as an Attachment to this Section.

b. Data Tabulations: Tabulate data at the specified sampling rates. Electronic data tabulations software: Microsoft Excel. File name: include commissioning test number: separate file for each test.

1) Tabulate data in a table format.
   a) Cover sheet: identify: Contract number, equipment or system identification, commissioning test number, test date, control point nomenclature indexed with plaintext point names.
   b) Header: on each page: Contract number, equipment or system identification, commissioning test number, test date, sequential page number.
   c) Vertical columns: data for one control point per column.
   d) Horizontal rows: one data value per control point, per row. Order: sequential with earliest time at the top.
   e) Top row on each page: control point nomenclature for each column.
   f) Left-most column: the time at which each data value was recorded.

2) An example data tabulation is included as an Attachment to this Section.

   B. Print out data graphs collected during the commissioning test or commissioning test demonstration and attach it to the data form.

   C. Record, print out and attach to the data form operator activity during the time the trend log is running. Operator intervention which is not specified in the commissioning test procedure during the time the trend log is running will invalidate the test results.

1.05 SYSTEM ALARM LOGS

A. Daily at the start of days following a day in which commissioning tests or commissioning test demonstrations were performed, record and print out a log of alarms which occurred since the last log was printed.

   1. The intent of this requirement is to discover control system points or sequences left in manual or disabled conditions, equipment left disconnected, or setpoints left with abnormal values, or similar conditions which may have resulted from failure to fully restore systems to normal, automatic control following commissioning tests.

   2. Evaluate alarms to determine if the previous day's work resulted in any conditions that would not be considered “normal operation.”

   3. Conditions that would not be considered “normal operation” shall be reported on a commissioning issue report attached to the alarm log. Resolve as necessary.
PART 2 - PRODUCTS

2.01 TEST EQUIPMENT
   A. Provide test equipment and instrumentation, including consumable supplies, required to
      execute commissioning activities. Unless noted otherwise, test equipment and
      instrumentation remain the property of the Contractor.

2.02 PROPRIETARY TEST INSTRUMENTS
   A. Provide proprietary test instruments or tools required by the equipment manufacturer.
      Provide and operate the proprietary test instruments or tools as required for
      commissioning work.

PART 3 - EXECUTION

3.01 LEVEL 1 COMMISSIONING ACTIVITIES REQUIREMENTS
   A. Level 1 commissioning activities scope: Technical requirements for commissioning of
      HVAC are specified herein.
   B. Provide technicians, instrumentation, and tools to perform commissioning activities in
      accordance with accepted commissioning activity procedures at the direction of the
      Commissioning Coordinator.
   C. Scope of HVAC commissioning activities applies to all portions of the HVAC installation
      described in the test, from central equipment for heat generation and refrigeration
      through distribution systems to each conditioned space.
   D. Preparation
      1. Certify that HVAC, subsystems, and equipment have been completed, calibrated,
         and started; and are operating in accordance with Contract Documents.
      2. Testing Instrumentation: Install measuring instruments and logging devices to
         record test data in accordance with accepted commissioning test procedures as
         directed by the Commissioning Coordinator.
      3. Certify that HVAC instrumentation and control systems have been completed and
         calibrated; are operating according to the Contract Documents; and that pretest
         set points have been recorded.
      4. Set systems, subsystems, and equipment into operating mode to be tested (e.g.,
         normal shut down, normal auto position, normal manual position, unoccupied
         cycle, emergency power, and alarm conditions) in accordance with accepted
         commissioning test procedures as directed by the Commissioning Coordinator.
   E. Test all operating modes, interlocks, control responses, responses to abnormal or
      emergency conditions, and verify proper response of building automation system
      controllers and sensors.
   F. Perform tests using design conditions whenever possible.
G. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Provide equipment to simulate loads. Set simulated conditions in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator. Document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

H. Request approval to alter set points when simulating conditions is not practical.

I. Request approval to alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.

J. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Sound Transit. After deficiencies are resolved, reschedule tests.

K. Where seasonal testing is specified, complete appropriate initial commissioning tests and documentation within the Construction Period. Schedule and execute seasonal tests when specified conditions are expected.

3.02 LEVEL 1 AND LEVEL 2 COMMISSIONING ACTIVITY PROCEDURES

A. Submit level 1 commissioning activity test procedures and data forms for the following types of commissioning activities, requirements for which are specified herein.

1. Level 1 commissioning activities:
   a. Installation verification
   b. Static tests
   c. Start-up procedures
   d. Component tests
   e. Equipment tests
   f. System tests

B. Cooperate with the Commissioning Coordinator to develop level 2 commissioning activity test procedures and data forms related to the work of this Division. Provide information as needed, including interfaces with equipment and systems installed by others.

1. Level 2 commissioning activities:
   a. Intra-station system interface tests

3.03 LEVEL 1 INSTALLATION VERIFICATION CHECKLIST REQUIREMENTS

A. Scope: Installation verification requirements apply to the following:

1. Section 23 05 48 Vibration and Seismic Controls for HVAC Piping and Equipment
2. Section 23 09 00 Instrumentation and Control for HVAC
3. Section 23 23 00 Refrigerant Piping
4. Section 23 31 13 Metal Ducts
5. Section 23 33 00 Air Duct Accessories
6. Section 23 34 23 HVAC Power Ventilators
7. Section 23 37 23 HVAC Gravity Ventilators
8. Section 23 41 00 Particulate Air Filtration
9. Section 23 34 23, HVAC Power Ventilators
10. Section 23 73 13 Modular Indoor Central Station Air Handling Units
11. Section 23 74 13 Packaged, Outdoor, Central Station Air Handling Units
12. Section 23 81 23 Computer Room Air Conditioners

B. Installation Verification Scope: Technical requirements for Installation Verification of HVAC are specified herein.

C. Installation verification checklist forms shall include the following:

1. Organized to prompt the installer to check off quality criteria for each discrete portion of the Work.
2. Identify the system or features to which the installation verification checklist applies at the top of the form.
3. Section for verification of delivery of accepted materials.
4. Section for condition of materials at delivery.
5. Section for installation. Include manufacturer’s installation instructions.
6. Space at the end of the form for the installer to print their name and company name, fill in the date, and sign or initial.
7. Space to identify the area of work for which the installer is executing the Installation Verification Checklist.
8. Description of the quality criteria as it pertains to the specific work. Include a check-box for each criterion.

D. Quality Criteria: Installation verification checklists shall address the following quality criteria.

1. Make and model match accepted submittals, including for motors, full load amperage rating and winding insulation class.
2. Equipment is installed without visible damage.
3. Location is as indicated on drawings.
4. Equipment is accessible for maintenance using safe work practices.
5. There is sufficient space to remove and replace components intact without demolishing other work.
6. Air handling equipment surfaces are clean and free of dust, dirt, oil and other contaminants.
7. Surfaces exposed to supply and return air flows are as clean as when they were manufactured.

8. Air filters fit tight to avoid air leakage around the filters. Special attention to tight closure of the space between the edges of slide-out filter frames and the access door.

E. Fill out and sign installation verification checklists for HVAC while the Work is being installed. The intent is for the installing tradesperson to fill out and sign the installation verification checklist as work proceeds to improve the quality of the installation. Retain completed installation verification checklists on site for review.

F. Before performing a commissioning test, submit completed installation verification checklists for work included in the commissioning test.

3.04 LEVEL 1 INSTALLATION VERIFICATION

A. Installation verification checklists are required for the following, minimum:

1. 2308-IV-01 Vibration and seismic controls for HVAC piping and equipment
2. 2308-IV-02 Instrumentation and control for HVAC
3. 2308-IV-03 Refrigerant piping
4. 2308-IV-04 Metal ducts and accessories
5. 2308-IV-05 HVAC power ventilators
6. 2308-IV-06 HVAC gravity ventilators
7. 2308-IV-07 Particulate air filtration
8. 2308-IV-08 Modular indoor central station air handling units
9. 2308-IV-09 Packaged, outdoor, central station air handling units
10. 2308-IV-10 Computer room air conditioners

3.05 LEVEL 1 STATIC TESTS

A. 2308-ST-01: Duct Leakage

1. System/Equipment to be Tested:
   a. Air handling ducts, 23 31 13 Metal Ducts

2. Functions to be Tested:
   a. Ducts and air handling unit casing leakage.
   b. Demonstrate a sample of 15 percent of supply and exhaust ducts.

3. Conditions of the Test:
   a. Include in Static Test Procedures and Data Forms submittal:
1) Instrumentation to be used, including orifice calibration. Select orifices that will register 0.2” w.g. static pressure differential, minimum, at the allowable rate of leakage for each test.

2) Leakage testing plan showing how ducts will be divided if testing will be performed in sections.

3) Calculations showing the maximum allowable leakage for each unit and for each section of ducts to be tested.

b. Test in accordance with SMACNA Air Duct Test Manual.

c. Seal off each system or section if applicable, securely blanking off inlets and discharges to the section.

d. Attach a formed collar in one of the blank-offs in the section to be tested.

e. Connect a leak test unit to the formed collar. Leak test unit shall include a pressurization fan and calibrated orifice to measure flow.

f. Positively pressurize ducts and air handling unit casings to the pressures indicated below for each class of ducts:

1) 1.5 inch w.g. for ducts where fan design static (ESP) is listed below 1 inch w.g.

2) 3.0 inch w.g. for ducts where fan design static (ESP) is listed below 2 inch w.g.

3) 4.0 inch w.g. for ducts where fan design static (ESP) is listed below 4 inch w.g.

g. Positively and negatively pressurize ducts within tunnel shafts to 10 inch w.g.

h. Record duct leakage as orifice static pressure differential and corresponding flow rate in CFM using the orifice calibration chart.

i. Air handling units shall be tested to the same criteria as ducts of the same pressure class.

4. Acceptable Results:

a. Total leakage shall not exceed 1.0 percent of the entire system capacity.

b. If the system is tested in sections:

1) Leakage for a section shall not exceed 1.0 percent of the maximum design volume of air handled by that section.

2) The sum of the leakage of the individual sections shall not exceed 1.0 percent of the entire system capacity.

c. Leakage concentrated at one point may result in objectionable noise, even if the system meets the leakage criteria. Locate the point source(s) of noisy leakage and correct the offending condition.

B. 2308-ST-02: Hydronic Pipe Leakage
1. System/Equipment to be Tested:
   a. Hydronic piping, 23 21 13 Hydronic Piping

2. Functions to be Tested:
   a. Hydronic pipe leakage.

3. Conditions of the Test:
   a. Prerequisites: The following prerequisites shall be successfully completed before start-up. Completion of flushing and cleaning requirements in accordance with Section 23 21 13 Hydronic Piping, Field Quality Control Article.
   b. Include in Static Test Procedures and Data Forms submittal: Hydronic pipe leakage testing plan showing how pipes will be divided if testing will be performed in sections.
   c. Perform test on hydronic piping in accordance with Section 23 21 13 Hydronic Piping, Field Quality Control Article. Test period shall be four hours.

4. Acceptable Results:
   a. Test results meet criteria in Section 23 21 13 Hydronic Piping, Field Quality Control Article.
   b. Test pressure at the end of the test period shall be not less than 98 percent of pressure at the start of the test period.

3.06 LEVEL 1 START-UP

A. 2308-SU-01: Air Handling Unit Start-up

1. System/Equipment to be Tested:
   a. Air Handling Units (N05-AHU-XX[A1]), Section 23 73 13 Modular Indoor Central Station Air Handling Units

2. Functions to be Tested:
   a. Start-up of air handling units.

3. Conditions of the Test:
   a. Prerequisites: The following prerequisites shall be successfully completed before start-up.
      1) Building management systems shall be complete and functional at the time of this test.
      2) Complete level 1 static test 2308-ST-01: Duct Leakage with acceptable results.
      3) Air handling units and ducts shall be clean, and filters installed.
4) Complete installation verification and testing of low-voltage electrical distribution materials and equipment serving the equipment.

b. Verify installation and perform startup of units in accordance with manufacturer’s written installation and startup procedures.

c. Verify installation and perform startup of units in accordance with startup service requirements of Section 23 73 13 Modular Indoor Central Station Air Handling Units.

d. Manufacturer-approved personnel shall start-up air handling units per manufacturer’s written procedures. Record results on manufacturer’s approved forms.

4. Acceptable Results:

a. Documented acceptable installation and startup in accordance with manufacturer’s requirements and contract documents.

B. 2308-SU-02: Dry Cooler Start-up

1. System/equipment to be tested:

a. Dry Cooler (N05-DC-01[A2])

2. Functions to be tested:

a. Start-up of dry cooler.

3. Conditions of the test:

a. Prerequisites: The following prerequisites shall be successfully completed before start-up.

1) Building management systems shall be complete and functional at the time of this test.

2) Complete level 1 static test 2308-ST-02: Hydronic Pipe Leakage with acceptable results, as applicable.

3) Complete level 1 installation verification and level 1 commissioning testing of low-voltage electrical distribution materials and equipment serving the equipment.

b. Verify installation and perform startup of units in accordance with Startup Service requirements of Section 23 81 23, Computer Room Air Conditioners and in accordance with manufacturer’s written installation and startup procedures.

c. Manufacturer-approved personnel shall start-up air handling units per manufacturer’s written procedures. Record results on manufacturer’s approved forms.

4. Acceptable Results:

a. Documented acceptable installation and startup in accordance with manufacturer’s requirements and contract documents.
C. 2308-SU-03: Air Conditioning Units Start-up

1. System/equipment to be tested:
   a. Air Conditioning Units (N05-ACU-XX[A3])

2. Functions to be tested:
   a. Start-up of air conditioning units.

3. Conditions of the test:
   a. Prerequisites: The following prerequisites shall be successfully completed before start-up.
      1) Building management systems shall be complete and functional at the time of this test.
      2) Complete level 1 static test 2308-ST-01: Duct Leakage with acceptable results, as applicable.
      3) Complete level 1 static test 2308-ST-02: Hydronic Pipe Leakage with acceptable results, as applicable.
      4) Complete level 1 installation verification and level 1 commissioning testing of low-voltage electrical distribution materials and equipment serving the equipment.
   b. Verify installation and perform startup of units in accordance with Startup Service requirements of Section 23 81 23, Computer Room Air Conditioners and in accordance with manufacturer’s written installation and startup procedures.
   c. Manufacturer-approved personnel shall start-up air handling units per manufacturer’s written procedures. Record results on manufacturer’s approved forms.

4. Acceptable Results:
   a. Documented acceptable installation and startup in accordance with manufacturer’s requirements and contract documents.

D. 2308-SU-04: Exhaust Fans

1. System/equipment to be tested:

2. Functions to be tested:
   a. Start-up of exhaust fans.

3. Conditions of the test:
   a. Prerequisites: The following prerequisites shall be successfully completed before start-up.
1) Building management systems shall be complete and functional at the time of this test.

2) Complete level 1 static test 2308-ST-01, duct leakage, with acceptable results.

3) Exhaust fans and ducts shall be clean.

4) Complete level 1 installation verification and level 1 commissioning testing of low-voltage electrical distribution materials and equipment serving the equipment.

b. Verify installation and perform startup of units in accordance with Field Quality Control requirements of Section 23 34 23, HVAC Power Ventilators, and in accordance with manufacturer's written installation and startup procedures.

c. Manufacturer-approved personnel shall start-up air handling units per manufacturer’s written procedures. Record results on manufacturer’s approved forms.

4. Acceptable Results:

a. Documented acceptable installation and startup in accordance with manufacturer’s requirements and contract documents.

3.07 LEVEL 1 COMPONENT TESTS

A. 2308-C-01: Backdraft Dampers

1. System/Equipment to be Tested:

a. Backdraft dampers, Section 23 33 00, Air Duct Accessories.

2. Functions to be Tested:

a. Tight closure against backdraft.

b. Low resistance to forward flow.

3. Conditions of the Test: Systems in which backdraft dampers are installed shall operate at their normal flow rates, pressures, and temperatures during the test. During test continuously monitor static pressure difference between locations immediately upstream and downstream of damper. Building management systems shall be complete and functional at the time of this test.

a. Start the fan connected to the duct in which the damper is mounted. Observe damper operation.

b. Stop the fan. Observe damper operation.

c. Create a backdraft at the damper location. Observe damper operation.

4. Acceptable Results:

a. When the fan runs, the damper begins to open at less than 0.02 inches water gauge pressure drop. The damper opens completely with less than 0.2 inches water gauge pressure drop.
b. With the fan off, the damper closes completely.
c. The damper remains closed under backdraft conditions.

B. 2308-C-02: Fire Dampers

1. System/Equipment to be Tested:
   a. Fire dampers, 23 33 00 Air Duct Accessories.

2. Functions to be Tested:
   a. Fire damper accessibility
   b. Fire damper operation

3. Conditions of the Test: Systems in which dampers are installed shall operate at their normal flow rates and temperatures during the test.
   a. With fan system operating in normal mode, remove the fusible link from fire dampers, allowing them to close unassisted. When satisfactory operation has been verified, reopen dampers and reinstall the fusible links.

4. Acceptable Results:
   a. Dampers close tight immediately upon release of the fusible link, without intervention or assistance. Dampers and fusible links are accessible.

C. 2308-C-03: Combination Fire/Smoke Dampers

1. System/Equipment to be Tested:
   a. Combination fire and smoke dampers (N05-FSD-XX[A5]), 23 33 00 Air Duct Accessories.

2. Functions to be Tested:
   a. Combination fire and smoke damper accessibility.
   b. Combination fire and smoke damper operation.

3. Conditions of the Test: Systems in which combination fire and smoke dampers are installed shall operate at their normal flow rates and temperatures during the test. Fire alarm control panel and building management systems shall be complete and functional at the time of this test.
   a. With fan system operating in normal mode, expose duct smoke detectors to smoke.
   b. Clear the smoke and reset the smoke detectors.
   c. Actuate the heat link on combination fire and smoke dampers, allowing them to close unassisted. When satisfactory operation has been verified, reopen dampers and reset the heat links.
4. Acceptable Results:
   a. Fire alarm system and LOS report the alarm. Combination fire and smoke dampers close. Supply (and return) fan(s) stop. After the appropriate time delay, outside (and return) air dampers close.
   b. Fan(s) do not restart automatically. Fan(s) restart only after smoke detectors have been reset and dampers have been commanded open.
   c. Dampers close tight immediately upon actuation of the heat link, without intervention or assistance.

D. 2308-C-04: Temperature Sensors and Transmitters

1. System/equipment to be tested:
   a. RTD and thermistor temperature sensors and transmitters, 23 09 00 Instrumentation and Control for HVAC.
   b. Temperature sensors provided with air conditioning units, N05-ACU-XX[Δ6], 23 81 23, Computer Room Air Conditioners

2. Functions to be tested:
   a. Accuracy of calibration

3. Conditions of the test:
   a. Compare temperature indication at HMI with calibration-grade instrument temperature when subjected to the same steady-state conditions at the following temperatures. Building management systems shall be complete and functional at the time of this test.

   1) At or near the high limit of the normal operating range to which the sensor will be subjected.

   2) At or near the low limit of the normal operating range to which the sensor will be subjected.

   3) With the sensor installed in its final, permanent position, compare the temperatures indicated by the sensor and the calibrator at midrange of the normal operating condition.

   b. Exception: For room temperature sensors, compare at room temperature not greater than 70°F.

   c. Demonstrate a random sample of 15 percent of room temperature sensors.

4. Acceptance Criteria:
   a. For conditions 1) and 2), temperature indication at HMI shall be within plus/minus 1.0 degree F of the calibration-grade instrument temperature. For condition 3), temperature indication at HMI shall be within plus/minus 2.0 degrees F of the calibration-grade instrument temperature.
b. Room temperature sensor temperature indication at HMI shall be within plus/minus 2.0 degrees F of the calibration-grade instrument temperature. If the Contractor fails to demonstrate acceptable results for all sample sensors, the sample will be rejected and the Contractor shall, after making corrections, demonstrate a repeat sample of double the number of sensors in the failed sample, at no additional cost to Sound Transit.

E. 2308-C-05: Pressure Transmitters/Transducers

1. System/equipment to be tested:
   a. Pressure Transmitters/Transducers used for air static pressure, water pressure, water differential pressure, and status sensors, 23 09 00 Instrumentation and Control for HVAC.

2. Functions to be tested:
   a. Accuracy of calibration

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Compare temperature indication at HMI with calibration-grade instrument pressure when subjected to the same steady-state conditions at the following pressures.
      1) At or near the high limit of the normal operating range to which the sensor will be subjected. Bench test is acceptable.
      2) At or near the low limit of the normal operating range to which the sensor will be subjected. Bench test is acceptable.
      3) With the sensor installed in its final, permanent position, compare the pressures indicated by the sensor and the calibrator at midrange of the normal operating condition.

4. Acceptance Criteria:
   a. At all conditions, error is less than plus or minus 1.2 percent of full scale.

F. 2308-C-06: Status Sensors

1. System/equipment to be tested:
   a. Status sensors for fans, pumps, 23 09 00 Instrumentation and Control for HVAC.

2. Functions to be tested:
   a. Accuracy of change of status indication.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Execute this test after completion of testing, adjusting and balancing for the associated fan or pump.
b. For fans:

1) Operate fan at lowest design flow as balanced. Adjust sensor to indicate fan running at a differential pressure approximately 10 percent below differential pressure at low design flow as balanced.

2) Shut down fan.

3) Restart fan.

c. For pumps:

1) Operate pump at lowest design flow as balanced. Adjust sensor to indicate pump running at a differential pressure approximately 10 percent below differential pressure at low design flow as balanced.

2) Shut down pump.

3) Restart pump.

4. Acceptance Criteria:

a. For fans:

1) HMI Run Feedback indicates fan is running.

2) HMI Run Feedback indicates fan is stopped.

3) HMI Run Feedback indicates fan is running.

b. For pumps:

1) HMI Run Feedback indicates pump is running.

2) HMI Run Feedback indicates pump is stopped.

3) HMI Run Feedback indicates pump is running.

G. 2308-C-07: Air Control Damper

1. System/equipment to be tested:

a. Air control dampers, actuators and associated controls, 23 09 00 Instrumentation and Control for HVAC, including outside air, return air and exhaust air dampers associated with air handling units and air conditioning units.

b. Motorized Dampers (N05-MDPR-XX)

c. Status sensors for damper position indication

2. Functions to be tested:

a. Performance of actuator in the absence of control signal.

b. Normal position of actuator in the absence of control power.
c. Actuator response to control signals.
d. Damper opening and closing.
e. Damper modulation, for modulating dampers
f. Damper position indication

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Prior to executing conditions listed below for this equipment, disconnect control signal. Observe the position of the actuator and of the controlled device.
   b. Prior to executing conditions listed below for this equipment, disconnect power. Observe the position of the actuator and of the controlled device.
   c. During tests listed below for this equipment, actuator shall be connected to the output terminal of the controller as required for final, permanent installation. If for any reason, the connection of the actuator to the controller is opened prior to Functional Completion, this test shall be repeated.
   d. Controlled fluids shall be flowing at or near design temperature, velocity and pressure.
   e. For each of the following conditions, observe response of actuator and HMI indication of damper position; directly observe position of damper blade(s) and the position of the damper shaft end marking.
   f. Command damper full open.
   g. For modulating damper, command damper to a randomly-selected partially closed position.
   h. Command damper full closed.
   i. For modulating damper, command damper to a randomly-selected partially open position.

4. Acceptance Criteria:
   a. Upon loss of control signal or control power, actuator drives controlled device to specified fail-to position.
   b. For all damper commands, damper smoothly moves to selected position without binding or hesitation. HMI shows correct position within plus or minus 5 degrees of rotation when compared to field observation of position.
   c. When damper is commanded closed, it closes tightly.

H. 2308-C-08: Automatic Control Valves

1. System/equipment to be tested:
a. Automatic control valves
b. Status sensors for valve position indication

2. Functions to be tested:
   a. Performance of actuator in the absence of control signal.
   b. Normal position of actuator in the absence of control power.
   c. Actuator response to control signals.
   d. Valve opening and closing.
   e. Valve modulation, for modulating valves
   f. Valve position indication

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Prior to executing conditions listed below for this equipment, disconnect control signal. Observe the position of the actuator and of the controlled device.
   b. Prior to executing conditions listed below for this equipment, disconnect power. Observe the position of the actuator and of the controlled device.
   c. During tests listed below for this equipment, actuator shall be connected to the output terminal of the controller as required for final, permanent installation. If for any reason, the connection of the actuator to the controller is opened prior to Functional Completion, this test shall be repeated.
   d. Controlled fluids shall be flowing at or near design temperature, velocity and pressure.
   e. For each of the following conditions, observe response of actuator and HMI indication of valve position; directly observe position of valve stem.
   f. Command valve full open.
   g. For modulating valve, command valve to a randomly-selected partially closed position.
   h. Command valve full closed.
   i. For modulating valve, command valve to a randomly-selected partially open position.

4. Acceptance Criteria:
   a. Upon loss of control signal or control power, actuator drives controlled device to specified fail-to position.
   b. For all damper commands, damper smoothly moves to selected position without binding or hesitation. HMI shows correct position within plus or minus 5 degrees of rotation when compared to field observation of position.
   c. When valve is commanded closed, it closes tightly.
3.08 LEVEL 1 EQUIPMENT TESTS

A. 2308-E-01: Air Conditioning Unit

1. System/equipment to be tested:
   a. Air conditioning units N05-ACU-XX, 23 81 23, Computer Room Air Conditioners

2. Functions to be tested:
   a. Monitoring and display of unit parameters.
   b. Compressor short-cycle control.
   c. Auto restart after power outage.
   d. Unit alarm annunciation.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Verify display of specified parameters.
   b. With compressor operating under normal automatic control, change the temperature set point so there is no call for cooling. Immediately upon compressor shutdown, restore the call for cooling. Observe the time elapsed until the compressor restarts.
   c. Record programmed time delay for automatic restart after power loss. Disconnect power from unit, including controller. Reconnect power. Observe the elapsed time until the unit restarts.
   d. Create an alarm condition for each of the following alarms:
      1) High Temperature
      2) Low Temperature
      3) High Humidity
      4) Low Humidity
      5) High Water Alarm - Lockout Unit Operation
      6) High Head Pressure
      7) Loss of Power
      8) Compressor Short Cycle
      9) Filter Clog
      10) Water Detected
      11) Smoke Detected
4. Acceptance Criteria:
   a. Unit parameters, including on-off status, operating mode indication, current day, time, temperature and humidity, display accurately.
   b. Elapsed time from compressor stop to compressor restart shall be no less than three minutes.
   c. Time delay for automatic restart is less than 9.9 minutes. Unit restarts at the end of the programmed time delay after restoration of power.
   d. For each alarm an audible signal is annunciated at the local control panel.

B. 2308-E-02: ACU Water-side Economizer Control

1. System/Equipment to be Tested:
   a. Air conditioning units N05-ACU-01, -04, -05, -06, -07, -08, -09, -10S, 23B1 23A8, Computer Room Air Conditioners

2. Functions to be Tested:
   a. Water-side economizer control.

3. Conditions of the Test: Building management systems shall be complete and functional at the time of this test.

4. Acceptable Results:
   a. Compressor motor: off. Three-way valve: modulates. Leaving water temperature: Set point +/- 1.0F
   b. Compressor motor: off. Three-way valve: modulates. Leaving water temperature: Set point +/- 1.0F
   c. Compressor motor: on. Three-way valve: modulates. Leaving water temperature: Set point +/- 1.0F

C. 2308-E-03: ACU Air-side Economizer Control

1. System/Equipment to be Tested:
   a. Air conditioning units N05-ACU-02, -03, 23 B1 23A9, Computer Room Air Conditioners

2. Functions to be Tested:
   a. Air-side economizer control.
3. Conditions of the Test: Building management systems shall be complete and functional at the time of this test.

4. Acceptable Results:
   a. Outside air (OSA), return air (RA), and exhaust air (EA) dampers modulate to control discharge air (DA) to 60F. Electric heating: off. If OSA temperature input was overridden, verify that dampers modulate to near 100 percent OSA. Compressor: off.
   b. OSA damper: minimum position. EA damper: minimum position. RA damper: inverse position of OSA damper. Electric heating: staged to control discharge air (DA) to 60F. Compressor: off.
   e. OSA damper: 100 percent open. EA damper: 100 percent open. RA damper: zero percent open. Electric heating: off. Compressor: on.

D. 2308-E-04: Condenser Water Pump Control

1. System/Equipment to be Tested:
   a. Condenser water pump package, [CWP-01, 23 81 23][A10], Computer Room Air Conditioners

2. Functions to be Tested:
   a. Control of condenser water differential pressure.

3. Conditions of the Test: Building management systems shall be complete and functional at the time of this test.
   a. No load: No air conditioning units (ACU's) operating
b. Minimum load: Enable ACU-04 and after a two minute delay, create a call for cooling in associated space.

c. Maximum load: Enable all ACU's and create a call for cooling in associated spaces.

d. Modulating load: Disable ACU's, one at a time, in random order.

4. Acceptable Results:

a. CWP-01 status: off.

b. CWP-01 status: starts upon call for cooling from ACU-04. Condenser water differential pressure is at setpoint +/-1.0 percent.

c. Condenser water differential pressure is at setpoint +/-1.0 percent.

d. Condenser water differential pressure is at setpoint +/-1.0 percent. When no ACU's are running, the CWP stops.

E. 2308-E-05: Dry Cooler Capacity - False Load, Seasonal Test

1. System/Equipment to be Tested:

a. Dry cooler, [N05-DC-01, 23 81 23][A11], Computer Room Air Conditioners

2. Functions to be Tested:

a. Heat rejection capacity at design conditions.

3. Conditions of the Test: Building management systems shall be complete and functional at the time of this test.

a. Full load: All connected air conditioning units (ACU's) operating with full scheduled loads. Outside air at design conditions.

4. Acceptable Results:

a. Capacity is 95 percent of scheduled capacity, minimum.

3.09 LEVEL 1 SYSTEM TESTS

A. 2308-S-01: Air Handling Unit Control - Occupancy

1. System/equipment to be tested:

a. Air handling units (N05-AHU-03, N05-AHU-05, N05-AHU-06, N05-AHU-10, N05-AHU-12[A12]), Section 23 73 13 Modular Indoor Central Station Air Handling Units.

b. Associated exhaust fans.

c. BMS sequence of control.

2. Functions to be tested:

a. Occupied and unoccupied mode scheduling.
3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Review occupied and unoccupied schedule times.
   b. Command unit in unoccupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.
   c. Activate occupancy override.
   d. Observe control at end of override period. Temporary change of BMS clock time may be used to accelerate progress to end of override period.
   e. Command unit in occupied mode. Temporary change of BMS clock time may be used.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.
   a. Unoccupied from 1:00 AM to 5:00 AM daily. Else occupied.
   b. AHU supply fan is off. OSA damper is closed. Associated exhaust fan is off. Bypass damper closed.
   c. BMS timer initiates two-hour override to occupied mode. AHU supply fan is on low speed. OSA damper is open. Associated exhaust fan is on low speed. Associated combination fire smoke dampers are open. Bypass damper closed.
   d. At the end of the override period, unit returns to unoccupied mode as verified in the previous step.
   e. AHU supply fan is on low speed. OSA damper is open. Associated exhaust fan is on. Associated combination fire smoke dampers are open. Bypass damper closed.

B. 2308-S-02: Air Handling Unit Control - Unoccupied Mode

1. System/equipment to be tested:
   a. Air handling units (N05-AHU-03, N05-AHU-05, N05-AHU-06, N05-AHU-10, N05-AHU-12[A13]), Section 23 73 13 Modular Indoor Central Station Air Handling Units.
   b. Associated exhaust fans.
   c. BMS sequence of control.

2. Functions to be tested:
   a. Unoccupied control.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Review deadband between fan start and fan stop temperature setpoints.
b. Command unit in unoccupied mode, initially with no call for heating or cooling. Temporary change of BMS clock time may be used. Temporarily lock out supply fan motor. Create a call for heating.

c. Release the supply fan motor lockout. Observe response for 5 minutes or until it is evident that the acceptance criteria have been met.

d. Satisfy call for heating.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.

a. Deadband is not less than 5 degrees F.

b. AHU supply fan does not operate. Heating coil is locked out due to negative fan run status feedback. Bypass damper closed.

c. AHU starts in occupied mode with supply fan and associated exhaust fan operating on low speed. OSA damper is open. Associated combination fire smoke dampers are open. Heating coil stages to maintain duct supply heating setpoint plus 5 degrees F, minus 0 degrees F. Bypass damper closed.

d. Unit returns to unoccupied mode. Bypass damper closed.

C. 2308-S-03: Air Handling Unit Control - Occupied Mode

1. System/equipment to be tested:

   a. Air handling units (N05-AHU-03, N05-AHU-05, N05-AHU-06, N05-AHU-10, N05-AHU-12(A14)), Section 23 73 13 Modular Indoor Central Station Air Handling Units.

   b. Associated exhaust fans.

   c. BMS sequence of control.

2. Functions to be tested:

   a. Occupied mode control

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.

   a. Start test with AHU in unoccupied mode. Then command unit in occupied mode. Temporary change of BMS clock time may be used. Create a call for heating (average space air temperature below 45 degree F setpoint).

   b. End call for heating. No call for heating or cooling.

   c. Create a call for cooling (average space air temperature one degree F above cooling setpoint).

   d. End call for cooling.

   e. Command unit in unoccupied mode.
4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices. For all conditions, supply fan and exhaust fan maintain the same pressure relationship to adjacent spaces (i.e. always positive, or always negative).

a. When occupied schedule begins, AHU operates in occupied mode with supply fan and associated exhaust fan operating at low speed. After 5 minutes with the average space air temperature below 45 degree F setpoint: Heating coil staged on to maintain duct supply heating setpoint plus 5 degrees F, minus 0 degrees F; OSA damper open; Associated combination fire smoke dampers open; Bypass damper open.

b. AHU operates in occupied mode with supply fan and associated exhaust fan operating at low speed. Heating coil is off. OSA damper is open. Associated combination fire smoke dampers are open. Bypass damper closed.

c. AHU operates in occupied mode with supply fan and associated exhaust fan speed modulated at speed proportionally between low speed and high speed. Heating coil is off. OSA damper is open. Associated combination fire smoke dampers are open. Bypass damper closed.

d. AHU operates in occupied mode with supply fan and associated exhaust fan operating at high speed. Heating coil is off (locked out). OSA damper is open. Associated combination fire smoke dampers are open. Bypass damper open.

e. AHU operates in occupied mode with supply fan and associated exhaust fan operating at low speed. Heating coil is off. OSA damper is open. Associated combination fire smoke dampers are open. Bypass damper closed.

f. AHU supply fan does not operate. Heating coil is locked out due to negative fan run status feedback. Bypass damper closed.

D. 2308-S-04: Air Handling Unit Control - AHU-14, AHU-15 [A15] Occupancy

1. System/equipment to be tested:

a. Air handling units (N05-AHU-14, N05-AHU-15[A16]), Section 23 73 13 Modular Indoor Central Station Air Handling Units.

b. Associated exhaust fans.

c. BMS sequence of control.

2. Functions to be tested:

a. Occupied and unoccupied mode scheduling.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.

a. Review occupied and unoccupied schedule times.

b. Command unit in unoccupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.
c. Activate occupancy override.

d. Observe control at end of override period. Temporary change of BMS clock time may be used to accelerate progress to end of override period.

e. Command unit in occupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.

   a. Unoccupied from 1:00 AM to 5:00 AM daily. Else occupied.
   b. AHU supply fans: off. OSA damper: closed. Associated exhaust fan: off.
   d. At the end of the override period, unit returns to unoccupied mode as verified in previous step.

E. 2308-S-05: Air Handling Unit Control - AHU-14, AHU-15 [A17] Unoccupied Mode

1. System/equipment to be tested:

   a. Air handling units (N05-AHU-14, N05-AHU-15[A18]), Section 23 73 13 Modular Indoor Central Station Air Handling Units.
   b. Associated exhaust fans.
   c. BMS sequence of control.

2. Functions to be tested:

   a. Unoccupied control.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.

   a. Command unit in unoccupied mode, initially with no call for heating or cooling. Temporary change of BMS clock time may be used. Temporarily lock out supply fan motor. Create a call for heating.
   b. Release the supply fan motor lockout. Observe response for 5 minutes or until it is evident that the acceptance criteria have been met.
   c. Satisfy call for heating.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.

   a. AHU supply fan does not operate. Heating coil is locked out due to negative fan run status feedback.
b. Lead AHU starts in occupied mode with associated exhaust fan operating at matching flow. OSA damper: open. Associated combination fire smoke dampers: open. Heating coil stages to maintain duct supply heating setpoint plus 5 degrees F, minus 0 degrees F.

c. Unit returns to unoccupied mode.

F. 2308-S-06: Air Handling Unit Control - \[\text{AHU-14, AHU-15}\] Occupied Mode

1. System/equipment to be tested:
   a. Air handling units (N05-AHU-14, N05-AHU-15), Section 23 73 13 Modular Indoor Central Station Air Handling Units.
   b. Associated exhaust fans.
   c. BMS sequence of control.

2. Functions to be tested:
   a. Occupied mode control

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Start test with AHU in unoccupied mode. Then command unit in occupied mode. Temporary change of BMS clock time may be used. Create a call for heating (duct supply temperature below 40 degree F setpoint).
   b. End call for heating. No call for heating or cooling.
   c. Create a call for cooling (duct supply temperature above setpoint).
   d. End call for cooling.
   e. Command unit in unoccupied mode.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices. For all conditions, supply fan and exhaust fan maintain the same pressure relationship to adjacent spaces (i.e. always positive, or always negative).
   a. When occupied schedule begins, lead AHU supply fan operates in occupied mode with associated exhaust fan operating at low speed. After 5 minutes with the duct supply temperature below 40 degree F setpoint, heating coil stages to maintain duct supply heating setpoint plus 5 degrees F, minus 0 degrees F. OSA damper: open. Associated combination fire smoke dampers: open.


G. 2308-S-07: Air Handling Unit Control - AHU-13 | AHU-13

1. System/equipment to be tested:
   a. Air handling unit N05-AHU-13 [A21], Section 23 73 13 Modular Indoor Central Station Air Handling Units.
   b. Associated return/exhaust fan N05-EFAN-03 [A22].
   c. Associated motorized dampers N05-MDPR-09 [A23] (Outside air, OSA), N05-MDPR-10 (Return air, RA), N05-MDPR-12 [A24] (Exhaust air, EA).
   d. BMS sequence of control.

2. Functions to be tested:
   a. Occupied and unoccupied mode scheduling.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Review occupied and unoccupied schedule times.
   b. Command unit in unoccupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.
   c. Activate occupancy override.
   d. Observe control at end of override period. Temporary change of BMS clock time may be used to accelerate progress to end of override period.
   e. Command unit in occupied mode. Temporary change of BMS clock time may be used.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.
   a. Unoccupied from 1:00 AM to 5:00 AM daily. Else occupied.
   c. BMS timer initiates two-hour override to occupied mode. AHU supply fan: on, low speed. OSA damper: minimum position. EA damper: minimum position. RA damper: modulated inversely to EA damper position. Associated exhaust fan is on low speed. Associated combination fire smoke dampers: open. Bypass damper: closed. At the end of the override period, unit returns to unoccupied mode as verified in the previous step.
d. At the end of the override period, unit returns to unoccupied mode as verified in the previous step.


H. 2308-S-08: Air Handling Unit Control - [AHU-13] Unoccupied

1. System/equipment to be tested:
   a. Air handling unit [N05-AHU-13][A27], Section 23 73 13 Modular Indoor Central Station Air Handling Units.
   b. Associated return/exhaust fan [N05-EFAN-03][A28].
   c. Associated motorized dampers [N05-MDPR-09] [A29](Outside air, OSA), [N05-MDPR-10] [A30](Return air, RA), [N05-MDPR-12] [A31](Exhaust air, EA).
   d. BMS sequence of control.

2. Functions to be tested:
   a. Unoccupied control.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Review deadband between fan start and fan stop temperature setpoints.
   b. Command unit in unoccupied mode, initially with no call for heating or cooling. Temporary change of BMS clock time may be used. Temporarily lock out supply fan motor. Create a call for heating.
   c. Release the supply fan motor lockout. Observe response for 5 minutes or until it is evident that the acceptance criteria have been met.
   d. Satisfy call for heating.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.
   a. Deadband is not less than 5 degrees F.
   b. AHU supply fan does not operate. Heating coil is locked out due to negative fan run status feedback. Bypass damper closed.
   c. AHU supply fan is on low speed. OSA damper: minimum position. EA damper: minimum position. RA damper: modulated inversely to EA damper position. Associated exhaust fan is on low speed. Associated combination fire smoke dampers: open. Bypass damper: closed. Heating coil stages to maintain duct supply heating setpoint plus 5 degrees F, minus 0 degrees F.
   d. Unit returns to unoccupied mode.
I. 2308-S-09: Air Handling Unit Control - AHU-13

1. System/equipment to be tested:
   a. Air handling unit N05-AHU-13, Section 23 73 13 Modular Indoor Central Station Air Handling Units.
   b. Associated return/exhaust fan N05-EFAN-03.
   c. Associated motorized dampers N05-MDPR-09 (Outside air, OSA), N05-MDPR-10 (Return air, RA), N05-MDPR-12 (Exhaust air, EA).
   d. BMS sequence of control.

2. Functions to be tested:
   a. Occupied mode control.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Start test with AHU in unoccupied mode. Then command unit in occupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.
   b. Create and maintain a call for cooling (average space temperature above cooling setpoint) until full cooling capacity is engaged.
   c. End call for cooling and immediately create and maintain a call for heating (average space temperature below heating setpoint) until the full heating capacity is engaged.
   d. End call for heating. No call for heating or cooling.
   e. Command unit in unoccupied mode.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.
   b. Heating coil: locked out. Bypass damper: open. OSA damper: modulates from minimum to open position simultaneously with EA damper modulation from minimum to open position, and with RA damper modulation to closed. After OSA, EA and RA dampers have completed modulation, AHU supply fan and associated exhaust fan speeds modulate from low to high. Associated combination fire smoke dampers are open.
   c. AHU supply fan and associated exhaust fan speeds modulate from high to low. OSA damper: modulates from open to minimum position simultaneously with EA damper modulation from open to minimum position, and with RA damper modulation inverse to EA damper position.
After OSA, EA and RA dampers have completed modulation, bypass damper: closes and heating coil stages on from low to high capacity.


e. AHU, exhaust fan, and dampers configured as previously verified.

J. 2308-S-10: Non-Pressurized Elevator Hoistway Damper Control

1. System/equipment to be tested:
   a. Motor-operated dampers MDPR-07 and MDPR-08.
   b. BMS sequence of control.

2. Functions to be tested:
   a. Temperature control.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. With outside air temperature above 78 degrees F, observe damper position.
   b. With outside air temperature below 78 degrees F, observe damper position.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices.
   b. Damper: closed.

K. 2308-S-11: Air Conditioning Unit Control - Occupancy

1. System/equipment to be tested:
   a. Air Conditioning Units (N05-ACU-XX), 23 81 23, Computer Room Air Conditioners and Dry Cooler.
   b. BMS sequence of control.

2. Functions to be tested:
   a. Occupied and unoccupied mode scheduling.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.
   a. Review occupied and unoccupied schedule times.
   b. Command unit in unoccupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.
c. Activate occupancy override.

d. Observe control at end of override period. Temporary change of BMS clock time may be used to accelerate progress to end of override period.

e. Command unit in occupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices. For all conditions, only ACU-07 has an unoccupied schedule; others operate in occupied mode at all times.

a. Unoccupied from 1:00 AM to 5:00 AM daily. Else occupied. For other units, no unoccupied schedule.


d. At the end of the override period, unit returns to unoccupied mode as verified in previous step.


L. 2308-S-12: Air Conditioning Unit Control - Occupied Mode

1. System/equipment to be tested:

a. Air Conditioning Units [N05-ACU-XX[A40]], 23 81 23, Computer Room Air Conditioners and Dry Cooler.

b. Dry Cooler, [N05-DC-01, 23 81 23[A41], Computer Room Air Conditioners and Dry Cooler.

c. Condenser Water Pump, [N05-CWP-01, 23 81 23[A42], Computer Room Air Conditioners and Dry Cooler.

d. BMS sequence of control.

2. Functions to be tested:

a. Occupied mode control.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.

a. Review occupied and unoccupied schedule times.

b. Command unit in unoccupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.

c. Activate occupancy override.
d. Observe control at end of override period. Temporary change of BMS clock time may be used to accelerate progress to end of override period.

e. Command unit in occupied mode with no call for heating or cooling. Temporary change of BMS clock time may be used.

4. Acceptance Criteria: For all conditions, HMI accurately reflects status of equipment and positions of devices. For all conditions, only ACU-07 has an unoccupied schedule; others operate in occupied mode at all times.

a. Unoccupied from 1:00 AM to 5:00 AM daily. Else occupied. For other units, no unoccupied schedule.


d. At the end of the override period, unit returns to unoccupied mode as verified in previous step.


M. 2308-S-13: Verification of Testing, Adjusting, and Balancing for HVAC

1. System/equipment to be tested:

a. Equipment and systems included in the scope of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

2. Functions to be tested:

a. Verification of final report of testing, adjusting, and balancing (TAB) data and measured TAB data.

3. Conditions of the test: Building management systems shall be complete and functional at the time of this test.

a. Commissioning Test Demonstration: Present a copy of final TAB report. The final TAB report consists of final TAB field data forms, after systems have been balanced within the tolerances of Section 23 05 93, Testing Adjusting and Balancing for HVAC, but before they are “cleaned up” for submittal as the final TAB report.

b. Commissioning Test Demonstration: Repeat readings in the presence of Sound Transit’s Witness of a sample of ten percent of the data recorded in the pre-final TAB report.

c. Commissioning Test Demonstration: Sound Transit’s Witness will select the sample at the time of the test.

4. Acceptance Criteria:

a. Commissioning Test Demonstration: Not more than twenty percent of the sampled readings shall deviate by more than ten percent from the recorded readings in the pre-final TAB report.
b. Commissioning Test Demonstration: No sample readings shall deviate by more than fifteen percent from the recorded readings in the pre-final TAB report.

c. Commissioning Test Demonstration: If the pre-final TAB report is rejected for excessive deviation between readings and reported conditions, make corrections to the system balance at no additional cost to Sound Transit. When corrections are complete, notify the A/E in writing that the system is ready for revalidation. Reimburse Owner for direct expenses incurred as the result of repeating the validation process.

3.10 ATTACHMENTS

A. Example trend log data graph: An example trend log data graph is included in Attachments herein. This example illustrates the format of specified trend log data graphs.

B. Example trend log data tabulation: An example trend log data tabulation is included in Attachments herein. This example illustrates the format of specified trend log data tabulations.

C. Example installation verification checklist: An example installation verification checklist is included in Attachments herein. This example is similar with respect to the level of rigor and detail to the installation verification checklist that the Contractor develops for use in the commissioning work.

D. Example test procedures: An example commissioning test procedure is included in Attachments herein. This example is similar with respect to the level of rigor and detail to the commissioning test procedures that the Contractor develops for use in the commissioning work.

END OF SECTION

ATTACHMENTS
Test #: 2308-S-12
Test Title: Economizer Control
System: AHU-09

Attachment A[A43]: Trend Log Data Graph

Test Title: Economizer Control
System: AHU-09
Attachment B: Trend Log Data Tabulation

Test #: 2308-S-12
Test Title: Economizer Control
System: AHU-09

Points in this data set:

<table>
<thead>
<tr>
<th>Point ID</th>
<th>Point Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI-12</td>
<td>OSA Temp</td>
</tr>
<tr>
<td>AI-73</td>
<td>OSA Volume</td>
</tr>
<tr>
<td>AO-24</td>
<td>Heating Demand</td>
</tr>
<tr>
<td>AO-25</td>
<td>Cooling Demand</td>
</tr>
<tr>
<td>AO-118</td>
<td>OSA Damper Cmd</td>
</tr>
</tbody>
</table>

Commissioning Test Data Tabulation

<table>
<thead>
<tr>
<th>Date / Time</th>
<th>OSA Temp AI-12</th>
<th>OSA Volume AI-73</th>
<th>Heating Demand AO-24</th>
<th>Cooling Demand AO-25</th>
<th>OSA Damper Cmd AO-118</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/15/10 0:00</td>
<td>59</td>
<td>3798</td>
<td>-</td>
<td>100.00</td>
<td>100</td>
</tr>
<tr>
<td>10/15/10 0:10</td>
<td>58.5</td>
<td>3865</td>
<td>-</td>
<td>60.00</td>
<td>100</td>
</tr>
<tr>
<td>10/15/10 0:20</td>
<td>58</td>
<td>3810</td>
<td>-</td>
<td>30.00</td>
<td>100</td>
</tr>
<tr>
<td>10/15/10 0:30</td>
<td>57.5</td>
<td>3856</td>
<td>-</td>
<td>25.00</td>
<td>100</td>
</tr>
<tr>
<td>10/15/10 0:40</td>
<td>57</td>
<td>3820</td>
<td>-</td>
<td>20.00</td>
<td>100</td>
</tr>
<tr>
<td>10/15/10 0:50</td>
<td>56.5</td>
<td>3910</td>
<td>5.00</td>
<td>15.00</td>
<td>100</td>
</tr>
<tr>
<td>10/15/10 1:00</td>
<td>56</td>
<td>3452</td>
<td>10.00</td>
<td>10.00</td>
<td>95</td>
</tr>
<tr>
<td>10/15/10 1:10</td>
<td>55.5</td>
<td>2810</td>
<td>10.00</td>
<td>5.00</td>
<td>85</td>
</tr>
<tr>
<td>10/15/10 1:20</td>
<td>55</td>
<td>1726</td>
<td>10.00</td>
<td>-</td>
<td>75</td>
</tr>
<tr>
<td>10/15/10 1:30</td>
<td>54.5</td>
<td>1247</td>
<td>15.00</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>10/15/10 1:40</td>
<td>54</td>
<td>985</td>
<td>20.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 1:50</td>
<td>53.5</td>
<td>955</td>
<td>25.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 2:00</td>
<td>53</td>
<td>962</td>
<td>30.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 2:10</td>
<td>52.5</td>
<td>973</td>
<td>35.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
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<td>52</td>
<td>894</td>
<td>40.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 2:30</td>
<td>51.5</td>
<td>928</td>
<td>70.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 2:40</td>
<td>51</td>
<td>963</td>
<td>80.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 2:50</td>
<td>50.5</td>
<td>942</td>
<td>90.00</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>10/15/10 3:00</td>
<td>50</td>
<td>865</td>
<td>100.00</td>
<td>-</td>
<td>32</td>
</tr>
</tbody>
</table>
Attachment C: Installation Verification Checklist

Installation Verification Checklist 2308-IV-02-EMF5
NON-REVERSIBLE EMERGENCY FAN
DRAFT, REV 0, 1OCT08

☐ First Check ☐ Repeat Check Date ________________
Fan Designation: C19-EMF-5 Sheet __1___ of ___54____

I. OBJECTIVES
   A. Document proper installation and condition of non-reversible emergency fans per contract requirements.
   B. Reference Section xxx
   C. Reference Section xxx
   D. Attachments: XYZ Installation and Startup checklist, 3 pages

II. SYSTEMS AND EQUIPMENT TO BE VERIFIED
   A. Supply and exhaust fans and associated controls:
      1. C19-EMF-5
      2. C19-EMF-6
      3. C19-EMF-7

III. CHECKLIST EQUIPMENT
   A. As required by attached installation checklist.

IV. CHECKLIST RESULTS
   A. Record observed conditions and results on the attached installation checklist in the spaces provided at the time of the inspection. Record results legibly in ink.
   B. If results do not comply with Acceptance Criteria, as denoted by a negative response, record the reason for the negative response and resolution in the "Negative Responses" section of the checklist.
   C. Describe any deviation, or elaboration, on the inspection procedure in the Notes sections. Attach additional pages for notes if necessary.
   D. Initial completed lines as each portion of the inspection is completed and recorded. Sign and date the Data Form when the tests are complete.

Notes:
DELIVERY CHECKLIST: Upon delivery of equipment to site, verify the following. Fill in information or circle "Yes/No" or "No" as appropriate.

<table>
<thead>
<tr>
<th>Model Verification</th>
<th>Submitted</th>
<th>Delivered</th>
<th>Contr Init</th>
<th>ST Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Manufacturer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Serial Number</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Arrangement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Heating Capacity (MBH/KW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Air flow, Design / Minimum (cfm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Fan Motor Power / Speed (hp / rpm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Voltage / Phase / Frequency (V / Ø / Hz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Motor FLA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Motor winding insulation class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Checks</th>
<th>Contr Init</th>
<th>ST Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Inspect the equipment for any shipping damage. Remove any foreign material such as tags or packing from any moving parts or from within the fan housing.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>13. Unit is free from physical damage</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>14. Air openings are sealed with plastic</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>15. All components present and in proper order</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>16. All access doors are operable</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>17. Installation and startup manual provided</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Yes/No</td>
<td></td>
</tr>
</tbody>
</table>
**INSTALLATION CHECKLIST:** Upon complete installation of equipment, verify the following. Fill in information or circle "Yes/No" or "No" as appropriate.

### Physical Checks

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Contr Init</th>
<th>ST Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Unit tags affixed, unobstructed, and legible</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Unit secured as required by manufacturer and specifications</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Adequate clearance around unit for service</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>All components accessible for maintenance and replacement</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Unit, as received from manufacturer, can be removed from and replaced in finished station without demolition of station finishes.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Internal vibration isolators in good condition and shipping bolts are removed, free to move</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>All fasteners are tight</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>Yes/No</td>
<td></td>
</tr>
</tbody>
</table>

### Ductwork

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Contr Init</th>
<th>ST Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Inlet and discharge ductwork size and configuration as required by accepted shop drawings and manufacturer's recommendations</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Adequate locations available for testing and balancing of unit</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>All dampers and sensors are accessible (access panels)</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>All dampers close tightly and stroke fully and easily</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Ductwork is clean and free of debris</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>No fittings within 2 ½ times fan wheel diameter</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>Yes/No</td>
<td></td>
</tr>
</tbody>
</table>
**PRE-START CHECKLIST:** Prior to start-up of equipment, verify the following. Fill in information or circle “Yes/No” or “No” as appropriate.

### Electrical

<table>
<thead>
<tr>
<th></th>
<th>Contr Init</th>
<th>ST Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.</td>
<td>Local disconnect installed in accessible location</td>
<td>Yes/No</td>
</tr>
<tr>
<td>35.</td>
<td>All electrical connections are tight</td>
<td>Yes/No</td>
</tr>
<tr>
<td>36.</td>
<td>All electrical components are grounded</td>
<td>Yes/No</td>
</tr>
<tr>
<td>37.</td>
<td>VFD installed (if applicable)</td>
<td>Yes/No</td>
</tr>
<tr>
<td>38.</td>
<td>Motor nameplate matches line characteristics: Voltage / Phase / Frequency (V / Ø / Hz)</td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td>Line: _____V/_____Ø/_____Hz</td>
<td>Motor:</td>
</tr>
<tr>
<td></td>
<td>_V/_____Ø/_____Hz</td>
<td></td>
</tr>
</tbody>
</table>

### Mechanical

<table>
<thead>
<tr>
<th></th>
<th>Contr Init</th>
<th>ST Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>39.</td>
<td>Lock out power source at disconnect switch.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>40.</td>
<td>Unit is clean.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>41.</td>
<td>Fans and motors lubricated and aligned.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>42.</td>
<td>Motor and fan drive pulleys aligned.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>43.</td>
<td>Fan belts have proper tension and are in good condition.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>44.</td>
<td>Protective shrouds for fans and belts in place and secure.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>45.</td>
<td>Filters installed properly (no bypass air) and are clean.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>46.</td>
<td>Turn motor, drive, and impeller by hand to see that no misalignment has taken place in shipment. Check V-belt drive for proper alignment and belt tension.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>47.</td>
<td>Check all bolts, screws, and fasteners, and tighten if necessary.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>48.</td>
<td>Make certain all setscrews, locking collars and bearing mounting bolts are secure.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>49.</td>
<td>Secure and check clearance of access doors, belt guards and inlet and outlet guards.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>50.</td>
<td>Complete and attach manufacturer's installation and prestart checks, if appropriate.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>51.</td>
<td>Jog the fan electrically and note rotation. Reverse two electrical leads, if necessary, to obtain proper rotation as marked with rotation arrow on fan. Do not allow the impeller to run backwards except momentarily.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>52.</td>
<td></td>
<td>Yes/No</td>
</tr>
</tbody>
</table>
NEGATIVE RESPONSES: Fill out the table for any negative responses noted above. Attach additional sheets as needed.

<table>
<thead>
<tr>
<th>Line #</th>
<th>Reason for Negative Response</th>
<th>Resolution</th>
<th>Contr Init</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SIGNATURE BLOCK: The undersigned have performed the above installation check and verified that the installation is complies with the manufacturer’s and contract requirements.

Company / Print Name / Signature / Date

Installing Contractor: ________________________________________________________________

Sound Transit witness: ______________________________________________________________

END OF INSTALLATION CHECKLIST
Attachment D: Commissioning Test

System Control Test Procedure and Data Form 15505.261-AHU1
AIR HANDLING UNIT, TYPE 1
APPROVED FOR TEST, REV 0, 1OCT08

☐ First Test ☐ Repeat Test  Test Date ________________

Unit: C19-AHU-1  Sheet __1___ of ___54____

I. OBJECTIVES

E. Verify performance of air handling units, type 1, including control input and output functions, alarms, and sequences of control.

F. Reference Section 15050.1.04

G. Reference Section 15505.2.08.

II. SYSTEMS AND EQUIPMENT TO BE TESTED

H. Type 1 air handling units, associated exhaust fans, associated dampers, associated electric heating coils, and associated controls:

1. C19-AHU-1, interlocked with C19-EF-1, and heating coils EHC-1, EHC-2, EHC-3
2. C19-AHU-2, interlocked with C19-EF-2, and heating coils EHC-4, EHC-5, EHC-6
3. C19-AHU-3, interlocked with C19-EF-20, and electric unit heater EUH-8
4. C19-AHU-4, interlocked with C19-EF-8
5. Air temperature sensors
6. Remote/local switch position reporting
7. Current sensing switches
8. Local smoke or fire condition reporting
9. Air filter differential pressure transducers (included?)
10. High speed fan start
11. Low speed fan start
12. Fan stop
13. Fire alarm control panel override fan stop
14. Schedule of operation
15. Sequence of control
16. Operator interface display
III. PREREQUISITES

I. Final installation of this system. ................................................................. Y___ N___

J. System is operating at normal pressure and temperature. .................... Y___ N___

K. Documented completion of Installation Checklist, 15505.211, including correction of deficient conditions. ......................................................... Y___ N___

L. The following Test Procedures have been completed with acceptable results:
   1. 15505.221: Air handling unit start-up ...................................................... Y___ N___
   2. 15951.121: FMS start-up ........................................................................ Y___ N___
   3. 15940.121: VFD start-up ........................................................................ Y___ N___
   4. 15940.141: VFD component performance test ......................................... Y___ N___
   5. 15881.451: Combination Fire/Smoke Dampers ....................................... Y___ N___
   6. 15990.161: TAB verification ................................................................. Y___ N___

IV. MINIMUM PARTICIPANTS

M. Owner's Witness

N. Test Technician: Mechanical System Contractor

O. Test Technician: Controls Contractor

V. TEST EQUIPMENT

P. Calibration-grade air temperature thermometer.

Q. Clamp-on ammeter.

R. Pneumatic squeeze bulb with tubing and barbed fittings

S. Air differential pressure calibration gauge

VI. TEST PROCEDURE

T. In accordance with general conditions of the contract, contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the performance of this test. Stop the test and notify the owner if it is determined that any part of the test cannot be performed safely.

U. Perform and document the following steps in the order listed. Acceptance criteria are listed below each step.
V. Air Filter Status Reporting: This section verifies the correct indication at the operator’s interface of the status of the air filter assembly relative to a threshold differential pressure, above which the filter condition is considered “abnormal.”

1. Record the threshold differential pressure (inches WG): ________________

2. Verify calibration of the differential pressure switch. Connect the squeeze bulb to apply pressure equally to the differential pressure calibration gauge and the filter differential pressure sensing switch. Gradually increase pressure with the squeeze bulb until the switch changes state.
   Record air differential pressure at which the switch changes state.
   \[ \Delta P \] ........................................................................................................ (In. WG) ________________
   Does the operator interface report the change of filter status from NORMAL to ABNORMAL? ................................................................. Y___ N___

3. Install air differential pressure calibration gauge to sense the same pressure differential sensed by the filter status sensing equipment. Operate the fan at high speed. With clean filters properly installed, verify that the filter status is reported as NORMAL.
   Record air differential pressure from the calibration gauge.
   Does the operator interface report the filter status as NORMAL? .................. Y___ N___

4. Restore system to normal operation.

W. Remote/Local Switch Position Reporting: This section verifies the correct indication at the operator’s interface of the position of the remote/local switch.

1. Place the remote/local switch in local mode.
   Does the operator interface report the switch position correctly? .................... Y___ N___

2. Place the remote/local switch in remote mode.
   Does the operator interface report the switch position correctly? .................... Y___ N___

3. Restore system to normal operation.

X. Current Sensing Switch Status Reporting: This section verifies ability to start the fan at high and low speeds and to stop the fan, and verifies the correct indication at the operator’s interface of the run condition of the fan.

1. Start the test with the fan OFF. Command the fan to HIGH speed.
   Does the operator interface report the fan speed correctly? ......................... Y___ N___

2. Command the fan to LOW speed.
   Does the operator interface report the fan speed correctly? ......................... Y___ N___
3. Command the fan OFF.
   Does the operator interface report the fan status correctly? Y___ N___

4. Restore system to normal operation.

Y. Local Smoke/Fire Status Reporting: This section verifies the correct indication at the operator’s interface of the local sensing of smoke or fire.

1. Cause the duct smoke detector to actuate by exposing it to smoke or magnetic field.
   Does the operator interface report the smoke detection for the correct device? Y___ N___

2. Cause the heat detector to actuate by exposing it to rated temperature.
   Does the operator interface report the heat detection for the correct device? Y___ N___

3. Restore system to normal operation.

Z. Fire Alarm Control Panel Override Fan Stop: This section verifies response to OVERRIDE FAN STOP command from the fire alarm control panel (FACP). The test will verify that the fan stops when running under both remote and local command, with the HOA switch in both HAND and AUTO position, and with the fan running at HI and LO speeds. It will also verify that the fan cannot be started after an OVERRIDE FAN STOP command until the command is cleared. Record the results of each step in the Data Table H that follows.

1. Start the test with the HOA switch in HAND and the fan running at HI speed. At the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command.
   Does the fan remain OFF? Y___ N___

2. At the FACP clear the OVERRIDE FAN STOP command. With the HOA switch in HAND and the fan running at LO speed, at the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command.
   Does the fan remain OFF? Y___ N___

3. At the FACP clear the OVERRIDE FAN STOP command. With the HOA switch in AUTO and the fan running at HI speed, at the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command.
   Does the fan remain OFF? Y___ N___

4. At the FACP clear the OVERRIDE FAN STOP command. With the HOA switch in AUTO and the fan running at LO speed, at the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command.
   Does the fan remain OFF? Y___ N___
Data Table H

For each test condition, record “S” for STOP, “R” for RUN.
Acceptance Criteria: In all test conditions, the fan stops and cannot be restarted while the OVERRIDE FAN STOP is active.

<table>
<thead>
<tr>
<th>Step</th>
<th>Speed</th>
<th>HOA = HAND</th>
<th>HOA = AUTO</th>
<th>RESTART</th>
<th>OK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HI</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>LO</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>1 / 3</td>
</tr>
<tr>
<td>3</td>
<td>HI</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2 / 4</td>
</tr>
<tr>
<td>4</td>
<td>LO</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

5. Restore system to normal operation.

AA. Schedule of Operation: This section verifies schedule of operation control of the fan. These units operate in response to a local time switch during human occupancy of the spaces.

BB. Sequence of Control: This section verifies system response to the sequence of control.

1. SYSTEM OFF CONDITION: Begin this step with the unit OFF by turning the time switch to the OFF position. Verify the following:
   1. The supply fan is off? ................................................................. Y___ N___
   2. The interlocked exhaust fan is off? .............................................. Y___ N___
   3. The outside air dampers are closed? ............................................ Y___ N___
   4. The exhaust air dampers are closed? ............................................ Y___ N___

2. SYSTEM START CONDITION: Adjust space temperature setpoints to create a demand for heating at the pre-heat electric coil. Command the unit to START by turning the time switch to the ON position. Verify the following:
   1. The supply fan starts ONLY after the outside air damper is full open? ...... Y___ N___
   2. The interlocked exhaust fan is starts ONLY after the exhaust damper is full open?
      ........................................................................................................ Y___ N___
   3. Electric heating is enabled ONLY after proof of supply air movement? ...... Y___ N___

3. SYSTEM RUN CONDITION: Immediately following system start, observe and verify the following:
   1. The supply fan runs continuously at LOW speed? ............................ Y___ N___

AA.

BB.

2. The interlocked exhaust fan runs continuously at LOW speed? .............. Y___ N__

3. The outside air dampers are fully OPEN? ............................................ Y___ N__

4. The exhaust air dampers are fully OPEN? ........................................... Y___ N__

4. SYSTEM RUN CONDITION TEMPERATURE CONTROL: Continue with the system in RUN CONDITION.

1. Record the electric pre-heat coil heating deadband value: ................... ________ °F

2. Adjust the room temperature setpoint for one room, to be selected by the Owner’s Witness at the time of the test, one degree F above current temperature plus heating deadband: The first stage of electric pre-heat is activated? ..................................................... Y___ N__

3. Adjust the room temperature setpoint for one room, to be selected by the Owner’s Witness at the time of the test, two degrees F (or as necessary) above current temperature plus heating deadband so that the second stage of electric pre-heat is activated. The second stage of electric pre-heat is activated? ................................................................. Y___ N__

4. Adjust the room temperature setpoint for one room, to be selected by the Owner’s Witness at the time of the test, five degrees F (or as necessary) above current temperature plus heating deadband so that the third stage of electric pre-heat is activated? Y___ N__

5. Adjust the room temperature setpoints such that a small heating demand is created in a room that is not controlling the AHU discharge air temperature. Then increase the offset to create a larger demand for heating. The zone electric heating coil is energized at the first stage of heating, then increases to the second stage of heating? ................................................................. Y___ N__

6. The outside air dampers are closed? .................................................... Y___ N__

7. The exhaust air dampers are closed? .................................................... Y___ N__

VII. ACCEPTANCE CRITERIA

CC. Observed results shall comply with acceptance criteria that appear below each step of the procedure above.

VIII. TEST RESULTS

DD. Record test conditions and results on the Test Procedure in the spaces provided above at the time of the test. Record results legibly in ink.
EE. If results do not comply with Acceptance Criteria above, terminate the test, complete a Commissioning Deficiency Report Form Part 1, make necessary corrections, repeat and document the Commissioning Test, submit Commissioning Deficiency Report Form Part 2, and repeat the Commissioning Test Demonstration.

If deficiencies noted, list Deficiency Report Numbers __________________________

FF. Describe any deviation, or elaboration, on the test procedure in the Notes sections. Attach additional pages for notes if necessary.

GG. Initial completed lines as each portion of the test is completed and recorded. Sign and date the Data Form when the tests are complete.

Issues Noted? Yes____ No____

Issue Report Numbers: ______________________________________________________

Notes:

Signatures: The undersigned have witnessed the above test and verified that the test was performed in accordance with the Approved Commissioning Test Procedure and that the results recorded were the actual results observed.

Company / Print Name / Signature / Date

Installing Contractor: ____________________________________________________________

Owner’s witness: ________________________________________________________________

END OF COMMISSIONING TEST PROCEDURE AND DATA FORM
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PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Commissioning process requirements for Tunnel Ventilation Equipment:

1. Level 1 commissioning activities for Tunnel Ventilation Equipment
2. Level 2 commissioning activities for Tunnel Ventilation Equipment
3. Support for Level 3 commissioning activities related to Tunnel Ventilation Equipment
4. Support for Level 4 commissioning activities related to Tunnel Ventilation Equipment

B. Related Sections:

1. Section 01 91 13, General Commissioning Requirements for: General commissioning process requirements, including definitions, submittals, scheduling, execution of commissioning activities, and reporting.
2. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC
3. Section 23 09 00, Instrumentation and Control for HVAC
4. Section 23 09 93, Sequence of Operations for HVAC Controls
5. Section 23 30 10, Tunnel Ventilation Equipment
6. Section 23 31 13, Metal Ducts
7. Section 23 33 00, Air Duct Accessories
8. Section 25 08 00, Commissioning of Integrated Automation
9. Section 25 60 00, Building Management System
10. Section 26 08 00, Commissioning of Electrical Systems

1.02 DEFINITIONS

A. Command: When used in the description of a commissioning activity, command means to use the station human machine interface (HMI) for the building management system (BMS) to control systems, equipment and components.

B. Systems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, equipment, and components.
C. Human Machine Interface (HMI): Equipment, software, and functional programming at the locations shown on the Plans and as specified in Division 25 Section Building Management System.

D. Tunnel Ventilation Equipment: Includes work of Division 23 Section Tunnel Ventilation Equipment, plus station smoke exhaust systems, equipment, and associated controls.

1.03 SYSTEM DESCRIPTION

A. Commissioning work includes: Furnish labor and material to accomplish building commissioning as specified in Division 01 Section “General Commissioning Requirements” and herein, including:

1. Provide to the Commissioning Coordinator preliminary O&M information for submittal.

2. Assist the Commissioning Coordinator in developing commissioning activity procedures and data forms submittals for work specified in this Section.

3. Provide information to the Commissioning Coordinator needed for control interface wiring diagrams submittals for the work of this Section.

4. Perform Level 1 commissioning activities specified in this Section, including installation verification, static tests, start-up, component tests, equipment tests, systems tests.

5. Perform Level 2 commissioning activities specified in this Section, including intra-station system interface tests.

6. Provide support for Level 3 commissioning activities, including jointly with the communications system contractor field testing points in the interface terminal strips, being present during level 3 testing with adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise. When material or equipment provided by this Division is found to be in conflict with specified criteria, adjust or replace said material or equipment, with the assistance of manufacturer as needed.

7. Provide support for Level 4 commissioning activities, including providing adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise during pre-revenue testing.

8. Operate equipment and system during commissioning activities as required by the Commissioning Coordinator.

9. Perform and document commissioning tests to verify readiness for commissioning test demonstration. Commissioning tests are specified herein.

10. Correct issues and repeat commissioning tests when results do not meet acceptance criteria.

11. Commissioning Test Demonstrations: General requirements for commissioning test demonstrations are specified in Division 01 Section 01 91 13, General Commissioning Requirements, Article 3.04, Level 1 and Level 2 Commissioning Activity Commissioning Test Demonstrations.

   a. Repeat commissioning tests on a sample basis to demonstrate acceptable performance: Level 1 Component, Equipment, and System
Commissioning Tests, and for Level 2 Intra-station system interface tests.

b. Record and submit commissioning test demonstration data and issues.

c. Correct issues and repeat commissioning test demonstration when results do not meet Acceptance Criteria.

12. Attend commissioning meetings as requested by the Commissioning Coordinator.

13. Report any inconsistencies or issues in system operations or performance.

14. Provide personnel to support commissioning test demonstration specified herein as requested by the Commissioning Coordinator.

15. In the event that a commissioning test demonstration fails, assist in determining the cause of failure. Make corrections as necessary.

16. Cooperate with Commissioning Coordinator to make equipment and systems ready for commissioning tests specified herein as early in the construction schedule as possible.

B. Cooperate with Commissioning Coordinator to accomplish commissioning work on schedule and in coordination with other trades.

1.04 DATA TREND LOGS

A. When required for specific tests under Part 3 herein, data trend logs shall comply with the following.

1. Format: Provide two hard copies of data graphs and one electronic copy of data graphs and data tabulations. Example data graphs and data tabulations similar to those required by this Article are included as attachments to this Section.

a. Data graphs format shall be annotated multiple data series graphs.

1) Where multiple data series are trend logged concurrently, present the data on a common horizontal time axis. Individual data series may be presented on a segmented vertical axis in order to avoid interference of one data series with another, and to accommodate different axis scale values.

2) Header: on each page: Contract number, equipment or system identification, commissioning test number, test date, sequential page number.

3) Annotate data graphs to identify the start time of each step of the test procedure in which a change to the system was manually initiated. Annotation shall include test procedure step number, minimum.

4) Annotate data graphs to identify each data plot with control point nomenclature and plaintext point name.

5) An example data graph is included as an Attachment to this Section.
b. Data Tabulations: Tabulate data at the specified sampling rates. Electronic data tabulations software: Microsoft Excel. File name: include commissioning test number: separate file for each test.

1) Tabulate data in a table format.

a) Cover sheet: identify: Contract number, equipment or system identification, commissioning test number, test date, control point nomenclature indexed with plaintext point names.

b) Header: on each page: Contract number, equipment or system identification, commissioning test number, test date, sequential page number.

c) Vertical columns: data for one control point per column.

d) Horizontal rows: one data value per control point, per row. Order: sequential with earliest time at the top.

e) Top row on each page: control point nomenclature for each column.

f) Left-most column: the time at which each data value was recorded.

2) An example data tabulation is included as an Attachment to this Section.

B. Print out data graphs collected during the commissioning test or commissioning test demonstration and attach it to the data form.

C. Record, print out and attach to the data form operator activity during the time the trend log is running. Operator intervention which is not specified in the commissioning test procedure during the time the trend log is running will invalidate the test results.

1.05 SYSTEM ALARM LOGS

A. Daily at the start of days following a day in which commissioning tests or commissioning test demonstrations were performed, record and print out a log of alarms which occurred since the last log was printed.

1. The intent of this requirement is to discover control system points or sequences left in manual or disabled conditions, equipment left disconnected, or setpoints left with abnormal values, or similar conditions which may have resulted from failure to fully restore systems to normal, automatic control following commissioning tests.

2. Evaluate alarms to determine if the previous day’s work resulted in any conditions that would not be considered “normal operation.”

3. Conditions that would not be considered “normal operation” shall be reported on a commissioning issue report attached to the alarm log. Resolve as necessary.
PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. Provide test equipment and instrumentation, including consumable supplies, required to execute commissioning activities. Unless noted otherwise, test equipment and instrumentation remain the property of the Contractor.

2.02 PROPRIETARY TEST INSTRUMENTS

A. Provide proprietary test instruments or tools required by the equipment manufacturer. Provide and operate the proprietary test instruments or tools as required for commissioning work.

PART 3 - EXECUTION

3.01 LEVEL 1 COMMISSIONING ACTIVITIES REQUIREMENTS

A. Level 1 commissioning activities scope: Technical requirements for commissioning of Tunnel Ventilation Equipment are specified herein.

B. Provide technicians, instrumentation, and tools to perform commissioning activities in accordance with accepted commissioning activity procedures at the direction of the Commissioning Coordinator.

C. Scope of Tunnel Ventilation Equipment commissioning activities applies to all portions of the Tunnel Ventilation Equipment installation described in the test.

D. Preparation

1. Certify that Tunnel Ventilation Equipment, subsystems, and equipment have been completed, calibrated, and started; and are operating in accordance with Contract Documents.

2. Testing Instrumentation: Install measuring instruments and logging devices to record test data in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator.

3. Certify that Tunnel Ventilation Equipment instrumentation and control systems have been completed and calibrated; are operating according to the Contract Documents; and that pretest set points have been recorded.

4. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions) in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator.

E. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

F. Perform tests using design conditions whenever possible.

G. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Provide equipment to simulate loads. Set simulated
conditions in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator. Document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

H. Request approval to alter set points when simulating conditions is not practical.

I. Request approval to alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.

J. If tests cannot be completed because of a deficiency outside the scope of the Tunnel Ventilation Equipment system, document the deficiency and report it to Sound Transit. After deficiencies are resolved, reschedule tests.

K. Where seasonal testing is specified, complete appropriate initial commissioning tests and documentation within the Construction Period. Schedule and execute seasonal tests when specified conditions are expected.

3.02 LEVEL 1 AND LEVEL 2 COMMISSIONING ACTIVITY PROCEDURES

A. Submit level 1 commissioning activity test procedures and data forms for the following types of commissioning activities, requirements for which are specified herein.

1. Level 1 commissioning activities:
   a. Installation verification
   b. Static tests
   c. Start-up procedures
   d. Component tests
   e. Equipment tests
   f. System tests

B. Cooperate with the Commissioning Coordinator to develop level 2 commissioning activity test procedures and data forms related to the work of this Division. Provide information as needed, including interfaces with equipment and systems installed by others.

1. Level 2 commissioning activities:
   a. Intra-station system interface tests

3.03 LEVEL 1 INSTALLATION VERIFICATION CHECKLIST REQUIREMENTS

A. Scope: Installation verification requirements apply to the following to the extent the cited Sections apply to Tunnel Ventilation Equipment work:

1. Section 23 05 48 Vibration and Seismic Controls for HVAC Piping and Equipment
2. Section 23 30 10 Tunnel Ventilation Equipment
3. Section 23 31 13 Metal Ducts

B. Installation Verification Scope: Technical requirements for Installation Verification of Tunnel Ventilation Equipment are specified herein.
C. Installation verification checklist forms shall include the following:

1. Organized to prompt the installer to check off quality criteria for each discrete portion of the Work.

2. Identify the system or features to which the installation verification checklist applies at the top of the form.

3. Section for verification of delivery of accepted materials.

4. Section for condition of materials at delivery.

5. Section for installation. Include manufacturer’s installation instructions.

6. Space at the end of the form for the installer to print their name and company name, fill in the date, and sign or initial.

7. Space to identify the area of work for which the installer is executing the Installation Verification Checklist.

8. Description of the quality criteria as it pertains to the specific work. Include a check-box for each criterion.

D. Quality Criteria: Installation verification checklists shall address the following quality criteria.

1. Make and model match accepted submittals, including for motors full load amperage rating and winding insulation class.

2. Equipment is installed without visible damage.

3. Location is as indicated on drawings.

4. Equipment is accessible for maintenance using safe work practices.

5. There is sufficient space to remove and replace components intact without demolishing other work.

6. Equipment surfaces are clean and free of dust, dirt, oil and other contaminants.

7. Surfaces exposed to air flows are as clean as when they were manufactured.

E. Fill out and sign installation verification checklists for Tunnel Ventilation Equipment while the Work is being installed. The intent is for the installing tradesperson to fill out and sign the installation verification checklist as work proceeds to improve the quality of the installation. Retain completed installation verification checklists on site for review.

F. Before performing a commissioning test, submit completed installation verification checklists for work included in the commissioning test.

3.04 LEVEL 1 INSTALLATION VERIFICATION

A. Installation verification checklists are required for the following, minimum:

1. 2308.1-IV-01 Vibration and seismic controls for Tunnel Ventilation Equipment

2. 2308.1-IV-02 Instrumentation and control for Tunnel Ventilation Equipment

3. 2308.1-IV-03 Emergency fans
4. 2308.1-IV-04 Smoke exhaust fans
   a. Storage conditions.
   b. Installed.

5. 2308.1-IV-05 Track dampers
   a. Linkage adjustment.
   b. External damper limit switches.
   c. Maintenance access to damper motors, limit switches, linkage connections, damper blade seals.

6. 2308.1-IV-06 Fan dampers, including:
   a. Linkage adjustment.
   b. External damper limit switches.
   c. Maintenance access to damper motors, limit switches, linkage connections, damper blade seals.

7. 2308.1-IV-07 Metal ducts and accessories

8. 2308.1-IV-08 Fan motor space heaters.
   a. Storage conditions.
   b. Installed.

9. 2308.1-IV-09 Damper motor space heaters.
   a. Storage conditions.
   b. Installed.

3.05 LEVEL 1 START-UP

A. 2308.1-SU-01: Smoke Exhaust Fans
   1. System/equipment to be tested:
      a. Exhaust Fans (N05-SEFN-XX), Section 23 30 10, Tunnel Ventilation Equipment.
      b. Exhaust fan motor space heaters.
   2. Functions to be tested:
      a. Start-up of smoke exhaust fans and motor space heaters.
   3. Conditions of the test:
a. Prerequisites: The following prerequisites shall be successfully completed before start-up.

1) Exhaust fans, air shafts and ducts shall be clean.
2) Complete level 1 installation verification and level 1 commissioning testing of low-voltage electrical distribution materials and equipment serving the equipment.

b. Verify installation and perform startup of units in accordance with requirements of Section 23 30 10, Tunnel Ventilation Equipment, and in accordance with manufacturer’s written installation and startup procedures.

c. Manufacturer-approved personnel shall start-up fans per manufacturer’s written procedures. Record results on manufacturer’s approved forms.

4. Acceptable Results:

a. Documented acceptable installation and startup in accordance with manufacturer’s requirements and contract documents.

B. 2308.1-SU-02: Emergency Fans

1. System/equipment to be tested:


b. Emergency fan motor space heaters.

2. Functions to be tested:

a. Start-up of emergency fans and motor space heaters.

3. Conditions of the test:

a. Prerequisites: The following prerequisites shall be successfully completed before start-up.

1) Fans, air shafts and ducts shall be clean.
2) Complete level 1 installation verification and level 1 commissioning testing of low-voltage electrical distribution materials and equipment serving the equipment.

b. Verify installation and perform startup of units in accordance with requirements of Section 23 30 10, Tunnel Ventilation Equipment, and in accordance with manufacturer’s written installation and startup procedures.

c. Manufacturer-approved personnel shall start-up fans per manufacturer’s written procedures. Record results on manufacturer’s approved forms.

4. Acceptable Results:

a. Documented acceptable installation and startup in accordance with manufacturer’s requirements and contract documents.
C. 2308.1-SU-03: Damper Start-up

1. System/equipment to be tested:
   a. Fan Dampers (N05-FD-XX[A2]), Section 23 30 10, Tunnel Ventilation Equipment.
   b. Tunnel Dampers (N05-TD-XX[A3]), Section 23 30 10, Tunnel Ventilation Equipment.
   c. Damper motor space heaters.
   d. Damper motor position limit switches.

2. Functions to be tested:
   a. Start-up of fan dampers, tunnel dampers and associated damper motor space heaters and damper motor position limit switches.

3. Conditions of the test:
   a. Prerequisites: The following prerequisites shall be successfully completed before start-up.
      1) Fans, air shafts and ducts shall be clean.
      2) Complete level 1 installation verification and level 1 commissioning testing of low-voltage electrical distribution materials and equipment serving the equipment.
   b. Verify installation and adjustment, and perform startup of units in accordance with requirements of Section 23 30 10, Tunnel Ventilation Equipment, and in accordance with manufacturer's written installation and startup procedures.
   c. Manufacturer-approved personnel shall start-up fans per manufacturer's written procedures. Record results on manufacturer's approved forms.

4. Acceptable Results:
   a. Documented acceptable installation, adjustment, and startup in accordance with manufacturer's requirements and contract documents.

3.06 LEVEL 1 COMPONENT TESTS


1. System/equipment to be tested:
   a. Fan motor bearing vibration sensors in Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Calibration and operation in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Verification of control programming of "alert" and "alarm" vibration levels.
3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Verify "alert" and "alarm" vibration level inputs.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Record "baseline", "alert", and "alarm" vibration levels as determined by manufacturer.

B. 2308.1-C-02: Fan Motor Bearing RTD – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Fan motor bearing RTD in Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Calibration and operation in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Verification of control programming of "alert" and "alarm" temperatures.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Verify "alert" and "alarm" temperature inputs.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Record "baseline", "alert", and "alarm" temperatures as determined by manufacturer.

C. 2308.1-C-03: Fan Winding RTD – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Fan Winding RTD in Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Calibration and operation in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.
   b. Verify "alert" and "alarm" temperature inputs.
a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD. Calibration temperature: Maximum temperature established by NEMA Standard MG1-12.42 for a Class F insulation system of the motors when measured by resistance method.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.2 Fan Motor Bearing Vibration and RTD and Winding RTD.

D. 2308.1-C-04: Fan Flow Switch – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Fan Flow Switches in Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Prerequisite: Execute this test after completion of testing, adjusting and balancing for the associated fan.
   b. Accuracy of change of status indication at HMI and at motor control terminal box.

3. Conditions of the test:
   a. Operate fan at lowest design flow as balanced. Adjust sensor to indicate fan running at a differential pressure approximately 10 percent below differential pressure at low design flow as balanced. For Emergency Fans, perform test with flow in forward and reverse directions.
   b. Shut down fan.
   c. Restart fan.

4. Acceptance Criteria:
   a. HMI Run Feedback and motor control terminal box indicates fan is running.
   b. HMI Run Feedback and motor control terminal box indicates fan is stopped.
   c. HMI Run Feedback and motor control terminal box indicates fan is running.

E. 2308.1-C-05: Fan Motor Space Heater

1. System/equipment to be tested:
   a. Space heaters in fan motor enclosures.

2. Functions to be tested:
   a. Interlock with fan operation.
   b. Temperature control within fan motors.
3. Conditions of the test:
   a. Verify space heaters are energized when fan is off.
   b. Verify space heaters are de-energized when fan is on.
   c. Measure wet bulb and dry bulb temperature inside motor enclosure during exposure to condensing ambient conditions below 40 degree F dry bulb.

4. Acceptance Criteria:
   a. Space heaters are energized when fan is off.
   b. Space heaters are de-energized when fan is on.
   c. Psychrometric conditions inside motor enclosure are non-condensing.

F. 2308.1-C-05: Damper Motor Space Heater

1. System/equipment to be tested:
   a. Space heaters in damper motors.

2. Functions to be tested:
   a. Temperature control within damper motor enclosures.

3. Conditions of the test:
   a. Measure wet bulb and dry bulb temperature inside motor enclosure during exposure to condensing ambient conditions below 40 degree F dry bulb.

4. Acceptance Criteria:
   a. Psychrometric conditions inside motor enclosure are non-condensing.

G. 2308.1-C-06: Damper Operator Position Limit Switch

1. System/equipment to be tested:
   a. Position limit switches in fan damper and tunnel damper operators.

2. Functions to be tested:
   a. Correct indication of damper operator position.

3. Conditions of the test:
   a. Prerequisites: Completion of Damper Tests specified in Section 23 30 10 Tunnel Ventilation Equipment, Article Field Testing and Training.
      b. Command damper operator full open and observe limit switch condition and HMI feedback of damper position.
      c. Command damper operator full closed and observe limit switch condition and HMI feedback of damper position.
d. Manually drive damper operator partially open and observe limit switch condition and HMI feedback of damper position.

4. Acceptance Criteria:
   a. Damper limit switch correctly indicates open position visibly at damper operator and at HMI.
   b. Damper limit switch correctly indicates closed position visibly at damper operator and at HMI.
   c. Damper limit switch correctly indicates position visibly at damper operator and at HMI as neither open nor closed.

H. 2308.1-C-07: Damper Blade-Mounted Position Limit Switch

1. System/equipment to be tested:
   a. External blade-mounted position limit switches in fan damper and tunnel damper sections.

2. Functions to be tested:
   a. Correct indication of damper position.

3. Conditions of the test:
   a. Prerequisites: Completion of Damper Tests specified in Section 23 30 10 Tunnel Ventilation Equipment, Article Field Testing and Training.
   b. Command damper section full open and observe limit switch signal at motor controller, and HMI feedback of damper position.
   c. Command damper section full closed and observe limit switch signal at motor controller, and HMI feedback of damper position.
   d. Manually drive damper section partially open and observe limit switch signal at motor controller, and HMI feedback of damper position.

4. Acceptance Criteria:
   a. Damper limit switch correctly indicates open position at motor controller, and at HMI.
   b. Damper limit switch correctly indicates closed position at motor controller, and at HMI.
   c. Damper limit switch correctly indicates position at motor controller, and at HMI as neither open nor closed.

3.07 LEVEL 1 EQUIPMENT TESTS

A. 2308.1-E-01: Fan Damper and Tunnel Damper – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Fan Dampers and Tunnel Dampers, Section 23 30 10 Tunnel Ventilation Equipment
2. Functions to be tested:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.1, Damper Tests
   b. Damper actuator operation at end of stroke.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.1, Damper Tests
   b. Drive damper open while observing the operation of damper actuator motors.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.1, Damper Tests
   b. Damper actuator motor stops when the damper section is full open.

B. 2308.1-E-02: Fan Vibration – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Fan vibration in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.3 Fan Vibration Tests.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.3 Fan Vibration Tests.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.3 Fan Vibration Tests.

C. 2308.1-E-03: Continuous Run – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Continuous run performance in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C.4 Continuous Run Test.

3. Conditions of the test:
a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 4 Continuous Run Test.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 4 Continuous Run Test.

D. 2308.1-E-04: Airflow – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Fan airflow volume performance in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 5 Airflow Test.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 5 Airflow Test.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 5 Airflow Test.

E. 2308.1-E-05: Starting – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Ability to withstand repeated starts and run conditions in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 6 Start Test.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 6 Start Test.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 6 Start Test.

F. 2308.1-E-06: Sound – Tunnel Ventilation Equipment

1. System/equipment to be tested:
   a. Emergency Fans and Smoke Exhaust Fans, Section 23 30 10 Tunnel Ventilation Equipment
2. Functions to be tested:
   a. Sound performance in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 7 Sound Test.

3. Conditions of the test:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 7 Sound Test.

4. Acceptance Criteria:
   a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 7 Sound Test.

3.08 LEVEL 1 SYSTEM TESTS

A. 2308.1-S-01: Tunnel Ventilation Interlocks

1. System/equipment to be tested:
   a. Emergency Fans, Smoke Exhaust Fans, Tunnel and Fan Dampers, Section 23 30 10 Tunnel Ventilation Equipment

2. Functions to be tested:
   a. Interlocks of fans and associated tunnel and fan dampers.

3. Conditions of the test:
   a. Start each fan in forward. Stop fan after successful start.
   b. Start each fan in reverse. Stop fan after successful start.

4. Acceptance Criteria:
   a. Before the fan starts in forward, at least one section of the associated tunnel or fan damper opens and the damper continues to open fully. After the fan stops, the associated damper closes completely.
   b. Before the fan starts in reverse, at least one section of the associated tunnel or fan damper opens and the damper continues to open fully. After the fan stops, the associated damper closes completely.

3.09 LEVEL 1 INTERSYSTEM TESTS

A. 2308.1-IS-01: Sound Attenuation

1. System/equipment to be tested:
   a. Tunnel ventilation equipment, including sound attenuators.

2. Functions to be tested:
   a. Attenuation of tunnel ventilation equipment noise.

3. Conditions of the test:
a. Prerequisite: Completion of Level 1 Equipment Test 2308.1-E-04: Airflow – Tunnel Ventilation Equipment, with acceptable results.

b. All tunnel ventilation fans operating at design conditions in exhaust mode.

4. Acceptance Criteria:

a. At station platform level: The noise at platform level shall not exceed 92 dBA as required by NFPA 130.

b. At grade level above the tunnel: As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article Sound Attenuators.

c. The self generated sound of any module corrected for face area adjustment factors shall not be greater than the sound power level of the fan unit minus the dynamic insertion loss of the element in any octave band.

B. 2308.1-IS-02: External Interface

1. System/equipment to be tested:

a. Tunnel ventilation equipment, including controllers.

b. Control interface terminal points, as detailed in the drawings.

c. Solid-state reduced-voltage controller fan motor monitoring status points communicated via low-level, open standard fieldbus type communications path.

2. Functions to be tested:

a. Monitoring of tunnel ventilation equipment via external interface.

b. Control of tunnel ventilation equipment via external interface.

3. Conditions of the test:

a. Tunnel ventilation equipment controllers' output points to external interface: Verify accuracy of control parameter value represented at the external interface, relative to the physical equipment response and to the value reported at the tunnel ventilation equipment controller for the same parameter.

b. External interface input points to tunnel ventilation equipment controller: Verify tunnel ventilation equipment controller and physical equipment response to external interface inputs is accurate.

4. Acceptance Criteria:

a. BMS outputs to external interface are accurately represented at the external interface, relative to the value reported at the HMI for the same parameter.

b. BMS response to external interface inputs is accurate.
3.10 LEVEL 3 INTER-STATION SYSTEM INTERFACE TESTS

A. 2308.1-IIS-01: Tunnel Ventilation Emergency Modes

1. System/equipment to be tested:


b. U240 [A5]: Emergency Fans, Smoke Exhaust Fans, Fan Dampers, and Tunnel Dampers

2. Functions to be tested:

a. Control in emergency operation modes. Reference Dwg. [N21-MC804] [A6], Mode Table.

3. Conditions of the test:

a. Prerequisites:

   1) Completion with acceptable results of Level 1 and Level 2 commissioning activities specified in Section 23 08 00 Commissioning of HVAC Systems for System/equipment to be tested.

   2) Completion with acceptable results of Level 1 and Level 2 commissioning activities specified for U240 [A7] System/equipment to be tested.

   3) Completion of System Control Contractor work related to this system.

b. In random order, initiate each emergency operation mode. Observe the response of equipment listed in the mode table.

4. Acceptance Criteria:

a. For each emergency operation mode, equipment can be operated as scheduled in the mode table and starts up within the time restrictions of NFPA 130.

B. 2308.1-IIS-02: Tunnel Airflow – Tunnel Ventilation Equipment

1. System/equipment to be tested:

a. U250 [A8]: Emergency Fans, Smoke Exhaust Fans, Fan Dampers, and Tunnel Dampers, Section 23 30 10 Tunnel Ventilation Equipment

b. U240 [A9]: Emergency Fans, Smoke Exhaust Fans, Fan Dampers, and Tunnel Dampers at Pine Street Stub Tunnel and at Capital Hill Station

c. Existing equipment:

   1) Westlake Station [A10]

   2) Pine Street Stub Tunnel [A11]

2. Functions to be tested:
a. Tunnel airflow performance in accordance with Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 9 Tunnel Airflow Test.

3. Conditions of the test:

a. Coordinate this test with Sound Transit and the U240 contractor. U240 contractor is responsible for a similar test. This test and the similar U240 test shall be performed simultaneously to allow end-to-end measurement of airflows for diagnostic purposes.

b. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 9 Tunnel Airflow Test.

4. Acceptance Criteria:

a. As specified in Section 23 30 10 Tunnel Ventilation Equipment, Article 3.02.C. 9 Tunnel Airflow Test.

C. 2308.1-IIS-03: Tunnel Ventilation Smoke Control Demonstration

1. System/equipment to be tested:


c. Existing equipment: [A14]
   1) Westlake Station
   2) Pine Street Stub Tunnel

2. Functions to be tested:


3. Conditions of the test:

a. Prerequisites:

   1) Completion with acceptable results of Level 1 and Level 2 commissioning activities specified in Section 23 08 00 Commissioning of HVAC Systems for System/equipment to be tested.

   2) Completion with acceptable results of Level 1 and Level 2 commissioning activities specified for U240[A16] System/equipment to be tested.

b. Coordinate this test with Sound Transit and the U240[A17] contractor. U240[A18] contractor is responsible for a similar test. This test and the similar U240[A19] test shall be performed simultaneously.

c. Generate smoke at locations indicated by the City of Seattle Fire Marshall. Initiate emergency operating mode indicated by the City of Seattle Fire Marshall.
4. Acceptance Criteria:
   a. For each location and emergency operation mode, equipment responds as scheduled in the mode table and smoke is cleared to the satisfaction of the Fire Marshall.

3.11 ATTACHMENTS

A. Example trend log data graph: An example trend log data graph is included in Attachments herein. This example illustrates the format of specified trend log data graphs.

B. Example trend log data tabulation: An example trend log data tabulation is included in Attachments herein. This example illustrates the format of specified trend log data tabulations.

C. Example installation verification checklist: An example installation verification checklist is included in Attachments herein. This example is similar with respect to the level of rigor and detail to the installation verification checklist that the Contractor develops for use in the commissioning work.

D. Example test procedures: An example commissioning test procedure is included in Attachments herein. This example is similar with respect to the level of rigor and detail to the commissioning test procedures that the Contractor develops for use in the commissioning work.

END OF SECTION
Test #: 2308-S-12
Test Title: Economizer Control
System: AHU-09

Attachment A: Trend Log Data Graph

Test #: 2308-S-12
Test Title: Economizer Control
System: AHU-09
**Attachment B: Trend Log Data Tabulation**

Test #: 2308-S-12

Test Title: Economizer Control

System: AHU-09

**Points in this data set:**

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<td>Cooling Demand</td>
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**Commissioning Test Data Tabulation**

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Attachment C: Installation Verification Checklist

Installation Verification Checklist 2308-IV-02-EMF5
NON-REVERSIBLE EMERGENCY FAN
DRAFT, REV 0, 1OCT08

☐ First Check ☐ Repeat Check

Fan Designation: C19-EMF-5

Date ____________________

Sheet ___1___ of ___38____

I. OBJECTIVES
   A. Document proper installation and condition of non-reversible emergency fans per contract requirements.
   B. Reference Section xxx
   C. Reference Section xxx
   D. Attachments: XYZ Installation and Startup checklist, 3 pages

II. SYSTEMS AND EQUIPMENT TO BE VERIFIED
   A. Supply and exhaust fans and associated controls:
      1. C19-EMF-5
      2. C19-EMF-6
      3. C19-EMF-7

III. CHECKLIST EQUIPMENT
    A. As required by attached installation checklist.

IV. CHECKLIST RESULTS
    A. Record observed conditions and results on the attached installation checklist in the spaces provided at the time of the inspection. Record results legibly in ink.
    B. If results do not comply with Acceptance Criteria, as denoted by a negative response, record the reason for the negative response and resolution in the "Negative Responses" section of the checklist.
    C. Describe any deviation, or elaboration, on the inspection procedure in the Notes sections. Attach additional pages for notes if necessary.
    D. Initial completed lines as each portion of the inspection is completed and recorded. Sign and date the Data Form when the tests are complete.

Notes:
**DELIVERY CHECKLIST:** Upon delivery of equipment to site, verify the following. Fill in information or circle "Yes/No" or "No" as appropriate.

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<th>Delivered</th>
<th>Contr Init</th>
<th>ST Init</th>
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<td>4. Arrangement</td>
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<td>6. Air flow, Design / Minimum (cfm)</td>
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<td>8. Voltage / Phase / Frequency (V / Ø / Hz)</td>
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</tbody>
</table>

**Physical Checks**

| 12. Inspect the equipment for any shipping damage. Remove any foreign material such as tags or packing from any moving parts or from within the fan housing. | Yes/No |
| 13. Unit is free from physical damage | Yes/No |
| 14. Air openings are sealed with plastic | Yes/No |
| 15. All components present and in proper order | Yes/No |
| 16. All access doors are operable | Yes/No |
| 17. Installation and startup manual provided | Yes/No |
| 18.                                      | Yes/No |

**INSTALLATION CHECKLIST:** Upon complete installation of equipment, verify the following. Fill in information or circle "Yes/No" or "No" as appropriate.

**Physical Checks**

| 19. Unit tags affixed, unobstructed, and legible | Yes/No |
| 20. Unit secured as required by manufacturer and specifications | Yes/No |
| 21. Adequate clearance around unit for service | Yes/No |
22. All components accessible for maintenance and replacement  Yes/No

23. Unit, as received from manufacturer, can be removed from and replaced in finished station without demolition of station finishes. Yes/No

24. Internal vibration isolators in good condition and shipping bolts are removed, free to move Yes/No

25. All fasteners are tight Yes/No

26.  

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</tr>
</thead>
<tbody>
<tr>
<td>27. Inlet and discharge ductwork size and configuration as required by accepted shop drawings and manufacturer's recommendations</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>28. Adequate locations available for testing and balancing of unit</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>29. All dampers and sensors are accessible (access panels)</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>30. All dampers close tightly and stroke fully and easily</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>31. Ductwork is clean and free of debris</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>32. No fittings within 2 ½ times fan wheel diameter</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>Yes/No</td>
<td></td>
</tr>
</tbody>
</table>

**PRE-START CHECKLIST:** Prior to start-up of equipment, verify the following. Fill in information or circle "Yes/No" or "No" as appropriate.

**Electrical**

| 34. Local disconnect installed in accessible location | Yes/No | |
| 35. All electrical connections are tight | Yes/No | |
| 36. All electrical components are grounded | Yes/No | |
| 37. VFD or Soft Start installed (if applicable) | Yes/No | |
| 38. Motor nameplate matches line characteristics: Voltage / Phase / Frequency (V / Ø / Hz) Line:_____ V/_____ Ø/_____ Hz  Motor:_____ V/_____ Ø/_____ Hz | Yes/No | |

**Mechanical**

<p>| 39. Lock out power source at disconnect switch. | Yes/No | |
| 40. Unit is clean. | Yes/No | |</p>
<table>
<thead>
<tr>
<th>Line</th>
<th>Reason for Negative Response</th>
<th>Resolution</th>
<th>Contr Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41.</td>
<td>Fans and motors lubricated and aligned.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>42.</td>
<td>Motor and fan drive pulleys aligned.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>43.</td>
<td>Fan belts have proper tension and are in good condition.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>44.</td>
<td>Protective shrouds for fans and belts in place and secure.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>45.</td>
<td>Filters installed properly (no bypass air) and are clean.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>46.</td>
<td>Turn motor, drive, and impeller by hand to see that no misalignment has taken place in shipment. Check V-belt drive for proper alignment and belt tension.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>47.</td>
<td>Check all bolts, screws, and fasteners, and tighten if necessary.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>48.</td>
<td>Make certain all setscrews, locking collars and bearing mounting bolts are secure.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>49.</td>
<td>Secure and check clearance of access doors, belt guards and inlet and outlet guards.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>50.</td>
<td>Complete and attach manufacturer’s installation and prestart checks, if appropriate.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>51.</td>
<td>Jog the fan electrically and note rotation. Reverse two electrical leads, if necessary, to obtain proper rotation as marked with rotation arrow on fan. Do not allow the impeller to run backwards except momentarily.</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>52.</td>
<td></td>
<td>Yes/No</td>
<td></td>
</tr>
</tbody>
</table>

**NEGATIVE RESPONSES:** Fill out the table for any negative responses noted above. Attach additional sheets as needed.

**SIGNATURE BLOCK:** The undersigned have performed the above installation check and verified that the installation is complying with the manufacturer’s and contract requirements.

Company / Print Name / Signature / Date

Installing Contractor: ____________________________________________________________

Sound Transit witness: __________________________________________________________

END OF INSTALLATION CHECKLIST
Attachment D: Commissioning Test

System Control Test Procedure and Data Form 15505.261-AHU1
AIR HANDLING UNIT, TYPE 1
APPROVED FOR TEST, REV 0, 10CT08

☐ First Test ☐ Repeat Test

Unit: C19-AHU-1

I. OBJECTIVES

E. Verify performance of air handling units, type 1, including control input and output functions, alarms, and sequences of control.

F. Reference Section 15050.1.04

G. Reference Section 15505.2.08.

II. SYSTEMS AND EQUIPMENT TO BE TESTED

H. Type 1 air handling units, associated exhaust fans, associated dampers, associated electric heating coils, and associated controls:
   1. C19-AHU-1, interlocked with C19-EF-1, and heating coils EHC-1, EHC-2, EHC-3
   2. C19-AHU-2, interlocked with C19-EF-2, and heating coils EHC-4, EHC-5, EHC-6
   3. C19-AHU-3, interlocked with C19-EF-20, and electric unit heater EUH-8
   4. C19-AHU-4, interlocked with C19-EF-8
   5. Air temperature sensors
   6. Remote/local switch position reporting
   7. Current sensing switches
   8. Local smoke or fire condition reporting
   9. Air filter differential pressure transducers (included?)
   10. High speed fan start
   11. Low speed fan start
   12. Fan stop
   13. Fire alarm control panel override fan stop
   14. Schedule of operation
   15. Sequence of control
   16. Operator interface display

III. PREREQUISITES

I. Final installation of this system. .................................................................Y___ N___

J. System is operating at normal pressure and temperature. .........................Y___ N___
K. Documented completion of Installation Checklist, 15505.211, including correction of deficient conditions. ...................................................................................................................Y___ N___

L. The following Test Procedures have been completed with acceptable results:

1. 15505.221: Air handling unit start-up .................................................................Y___ N___
2. 15951.121: FMS start-up ....................................................................................Y___ N___
3. 15940.121: VFD start-up ...................................................................................Y___ N___
4. 15940.141: VFD component performance test ...................................................Y___ N___
5. 15881.451: Combination Fire/Smoke Dampers .................................................Y___ N___
6. 15990.161: TAB verification ................................................................................Y___ N___

IV. MINIMUM PARTICIPANTS

M. Owner’s Witness

N. Test Technician: Mechanical System Contractor

O. Test Technician: Controls Contractor

V. TEST EQUIPMENT

P. Calibration-grade air temperature thermometer.

Q. Clamp-on ammeter.

R. Pneumatic squeeze bulb with tubing and barbed fittings

S. Air differential pressure calibration gauge

VI. TEST PROCEDURE

T. In accordance with general conditions of the contract, contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the performance of this test. Stop the test and notify the owner if it is determined that any part of the test cannot be performed safely.

U. Perform and document the following steps in the order listed. Acceptance criteria are listed below each step.

V. Air Filter Status Reporting: This section verifies the correct indication at the operator’s interface of the status of the air filter assembly relative to a threshold differential pressure, above which the filter condition is considered “abnormal.”

1. Record the threshold differential pressure (inches WG): ________________

2. Verify calibration of the differential pressure switch. Connect the squeeze bulb to apply pressure equally to the differential pressure calibration gauge and the filter differential pressure sensing switch. Gradually increase pressure with the squeeze bulb until the switch changes state.
   Record air differential pressure at which the switch changes state.
   \[ \Delta P \] (In. WG) __________________
   (In. WG) __________________
Does the operator interface report the change of filter status from NORMAL to ABNORMAL? .......................................................... Y___ N___

3. Install air differential pressure calibration gauge to sense the same pressure differential sensed by the filter status sensing equipment. Operate the fan at high speed. With clean filters properly installed, verify that the filter status is reported as NORMAL. Record air differential pressure from the calibration gauge.

Does the operator interface report the filter status as NORMAL?  
Record air differential pressure at which the switch changes state. 
ΔP .................................................................................................................. (In. WG) _________________

Does the operator interface report the filter status as NORMAL? ...................... Y___ N___

4. Restore system to normal operation.

W. Remote/Local Switch Position Reporting: This section verifies the correct indication at the operator's interface of the position of the remote/local switch.

1. Place the remote/local switch in local mode.

Does the operator interface report the switch position correctly? ...................... Y___ N___

2. Place the remote/local switch in remote mode.

Does the operator interface report the switch position correctly? ....................... Y___ N___

3. Restore system to normal operation.

X. Current Sensing Switch Status Reporting: This section verifies ability to start the fan at high and low speeds and to stop the fan, and verifies the correct indication at the operator’s interface of the run condition of the fan.

1. Start the test with the fan OFF. Command the fan to HIGH speed.

Does the operator interface report the fan speed correctly? ............................... Y___ N___

2. Command the fan to LOW speed.

Does the operator interface report the fan speed correctly? ............................... Y___ N___

3. Command the fan OFF.

Does the operator interface report the fan status correctly? ............................... Y___ N___

4. Restore system to normal operation.

Y. Local Smoke/Fire Status Reporting: This section verifies the correct indication at the operator’s interface of the local sensing of smoke or fire.

1. Cause the duct smoke detector to actuate by exposing it to smoke or magnetic field.

Does the operator interface report the smoke detection for the correct device? Y___ N___

2. Cause the heat detector to actuate by exposing it to rated temperature.

Does the operator interface report the heat detection for the correct device? .... Y___ N___

3. Restore system to normal operation.

Z. Fire Alarm Control Panel Override Fan Stop: This section verifies response to OVERRIDE FAN STOP command from the fire alarm control panel (FACP). The test will verify that the fan stops when running under both remote and local command, with the HOA switch in both HAND and AUTO position, and with the fan running at HI and LO speeds. It will also verify that the fan cannot be started after an OVERRIDE FAN STOP command until the command is cleared. Record the results of each step in the Data Table H that follows.
1. Start the test with the HOA switch in HAND and the fan running at HI speed. At the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command. Does the fan remain OFF? .................................................................Y___ N___

2. At the FACP clear the OVERRIDE FAN STOP command. With the HOA switch in HAND and the fan running at LO speed, at the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command. Does the fan remain OFF? .................................................................Y___ N___

3. At the FACP clear the OVERRIDE FAN STOP command. With the HOA switch in AUTO and the fan running at HI speed, at the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command. Does the fan remain OFF? .................................................................Y___ N___

4. At the FACP clear the OVERRIDE FAN STOP command. With the HOA switch in AUTO and the fan running at LO speed, at the FACP issue OVERRIDE FAN STOP command. After the fan stops, attempt to restart the fan without clearing the OVERRIDE FAN STOP command. Does the fan remain OFF? .................................................................Y___ N___

**Data Table H**

For each test condition, record “S” for STOP, “R” for RUN.

Acceptance Criteria: In all test conditions, the fan stops and cannot be restarted while the OVERRIDE FAN STOP is active.

<table>
<thead>
<tr>
<th>HOA = HAND</th>
<th>HOA = AUTO</th>
<th>RESTART</th>
<th>OK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Speed</td>
<td>HI</td>
<td>LO</td>
<td>HI</td>
</tr>
<tr>
<td>Response</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Restore system to normal operation.

AA. Schedule of Operation: This section verifies schedule of operation control of the fan. These units operate in response to a local time switch during human occupancy of the spaces.

BB. Sequence of Control: This section verifies system response to the sequence of control.

1. **SYSTEM OFF CONDITION:** Begin this step with the unit OFF by turning the time switch to the OFF position. Verify the following:

   1. The supply fan is off? .................................................................Y___ N___
   2. The interlocked exhaust fan is off? .................................................................Y___ N___
   3. The outside air dampers are closed? .................................................................Y___ N___
   4. The exhaust air dampers are closed? .................................................................Y___ N___
2. SYSTEM START CONDITION: Adjust space temperature setpoints to create a demand for heating at the pre-heat electric coil. Command the unit to START by turning the time switch to the ON position. Verify the following:

1. The supply fan starts ONLY after the outside air damper is full open? ......Y___ N___
2. The interlocked exhaust fan is starts ONLY after the exhaust damper is full open? ................................................................. Y___ N___
3. Electric heating is enabled ONLY after proof of supply air movement? ......Y___ N___

3. SYSTEM RUN CONDITION: Immediately following system start, observe and verify the following:

1. The supply fan runs continuously at LOW speed? ....................................... Y___ N___
2. The interlocked exhaust fan runs continuously at LOW speed? .................. Y___ N___
3. The outside air dampers are fully OPEN? .................................................... Y___ N___
4. The exhaust air dampers are fully OPEN? ................................................... Y___ N___

4. SYSTEM RUN CONDITION TEMPERATURE CONTROL: Continue with the system in RUN CONDITION.

1. Record the electric pre-heat coil heating deadband value: ................................________°F
2. Adjust the room temperature setpoint for one room, to be selected by the Owner’s Witness at the time of the test, one degree F above current temperature plus heating deadband: The first stage of electric pre-heat is activated? ................. Y___ N___
3. Adjust the room temperature setpoint for one room, to be selected by the Owner’s Witness at the time of the test, two degrees F (or as necessary) above current temperature plus heating deadband so that the second stage of electric pre-heat is activated. The second stage of electric pre-heat is activated? ................................................................. Y___ N___
4. Adjust the room temperature setpoint for one room, to be selected by the Owner’s Witness at the time of the test, five degrees F (or as necessary) above current temperature plus heating deadband so that the third stage of electric pre-heat is activated. The third stage of electric pre-heat is activated? .................................... Y___ N___
5. Adjust the room temperature setpoints such that a small heating demand is created in a room that is not controlling the AHU discharge air temperature. Then increase the offset to create a larger demand for heating. The zone electric heating coil is energized at the first stage of heating, then increases to the second stage of heating? ................................................................................. Y___ N___
6. The outside air dampers are closed? .......................................................... Y___ N___
7. The exhaust air dampers are closed? .......................................................... Y___ N___

VII. ACCEPTANCE CRITERIA

CC. Observed results shall comply with acceptance criteria that appear below each step of the procedure above.
VIII. TEST RESULTS

DD. Record test conditions and results on the Test Procedure in the spaces provided above at the time of the test. Record results legibly in ink.

EE. If results do not comply with Acceptance Criteria above, terminate the test, complete a Commissioning Deficiency Report Form Part 1, make necessary corrections, repeat and document the Commissioning Test, submit Commissioning Deficiency Report Form Part 2, and repeat the Commissioning Test Demonstration.

If deficiencies noted, list Deficiency Report Numbers

FF. Describe any deviation, or elaboration, on the test procedure in the Notes sections. Attach additional pages for notes if necessary.

GG. Initial completed lines as each portion of the test is completed and recorded. Sign and date the Data Form when the tests are complete.

Issues Noted? Yes____ No____

Issue Report Numbers:

Notes:

Signatures: The undersigned have witnessed the above test and verified that the test was performed in accordance with the Approved Commissioning Test Procedure and that the results recorded were the actual results observed.

Company / Print Name / Signature / Date

Installing Contractor: ________________________________

Owner’s witness: ________________________________

END OF COMMISSIONING TEST PROCEDURE AND DATA FORM
CONTRACT SPECIFICATIONS

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes control components for HVAC systems, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Control of HVAC systems and components not specified with factory controls in other Division 23 sections will be through the Building Management System as described in Section 25 60 00 and as indicated on the Contract Drawings.

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 23 05 00, Common Work Results for HVAC
2. Section 23 08 00, Commissioning for HVAC
3. Section 23 09 93, Sequence of Operations for HVAC Controls
4. Section 23 73 13, Modular Indoor Central Station Air Handling Units
5. Section 25 60 00, Building Management System

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. National Fire Protection Association (NFPA)
   a. 70 National Electric Code

2. Instrumentation, Systems, and Automation Society (ISA)
   a. ISA 50.00.01 Compatibility of Analog Signals for Electronic Industrial Process Instruments

3. National Electrical Manufacturers Association (NEMA)
   a. NEMA 250 Enclosures for Electrical Equipment (1000 V Maximum)

4. Air Movement and Control Association (AMCA)
   a. AMCA 500D Test Methods for Louvers, Dampers and Shutters

1.03 PROJECT COORDINATION

A. See Section 01 31 13, Project Coordination and Section 23 05 00, Common Work Results for HVAC, for requirements.
B. Coordinate equipment with Section 28 31 00, Fire Detection and Alarm, to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Section 26 29 13, Enclosed Controllers, to achieve compatibility with motor starters and annunciation devices.

1.04 SUBMITTALS

A. Product Data: For each control device indicated.

B. Shop Drawings:
   1. Schematic flow diagrams.
   2. Power, signal, and control wiring diagrams.
   3. Details of control panel faces.
   4. Damper schedule.

C. Software and firmware operational documentation.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to city of Seattle code authority, and marked for intended use.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

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

   2. All products shall be compatible with the existing Link Rail building management systems.

2.02 EQUIPMENT

A. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

   1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.

3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

B. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.03 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Available Manufacturers:
   a. BEC Controls Corporation
   b. Ebtron, Inc.
   c. Heat-Timer Corporation
   d. I.T.M. Instruments Inc.
   e. MAMAC Systems, Inc.
   f. RDF Corporation

2. Accuracy: Plus or minus 0.40 degrees F at calibration point.


4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.

5. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.

6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.

7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: Exposed.
   b. Set-Point Indication: Keyed.
   c. Thermometer: Exposed.
d. Color:
e. Orientation: Vertical.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Transmitter output signal: 4-20mA, loop powered.

C. RTDs and Transmitters:
1. Available Manufacturers:
   a. BEC Controls Corporation.
   b. MAMAC Systems, Inc.
   c. RDF Corporation.
2. Accuracy: Plus or minus 0.2 percent at calibration point.
4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
5. Averaging Elements in Ducts: 48 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: Exposed.
   b. Set-Point Indication: Keyed Exposed.
   d. Orientation: Vertical.
8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Transmitter output signal: 4-20mA, loop powered.

D. Pressure Transmitters/Transducers:
1. Available Manufacturers:
   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. TCS/Basys Controls.
f. Vaisala.

2. Air Differential-Pressure Transducers: diaphragm construction suitable for service, NEMA 4X Housing; minimum -4 to 10 inches of water operating pressure and tested to 11 pounds per square inch; linear output 4 to 20 mA.
   a. Accuracy: plus or minus 1.0 percent of full scale.

3. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
   a. Repetitive Accuracy: plus or minus 1.0 percent.

E. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   2. Orientation: Vertical.

F. Room sensor accessories include the following:
   1. Insulating Bases: For sensors located on exterior walls.
   2. Guards Locking, solid metal, ventilated.
   3. Adjusting Key: As required for calibration and cover screws.

2.04 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg. Wire to control terminals as “Run Feedback” signal.
   1. Repetitive Accuracy: plus or minus 1.0 percent.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump, internal screw set point adjustment. Wire to control terminals as “Run Feedback” signal.
   1. Deadband: 5 percent of range

C. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
   1. Minimum Rotation Travel: 5 degrees
   2. Maximum Rotation Travel: 360 degrees
   3. Temperature Limits: -40 to 180 degrees F.

D. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure, -10 to 180 degree F temperature limits, thumbscrew set point adjustment
   1. Available Manufacturers:
      a. Dwyer Instruments, Inc.
      b. BEC Controls Corporation.
2.05 ACTUATORS

A. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Available Manufacturers:
   a. Belimo Aircontrols (USA), Inc.
   b. Valves: Size for torque required for valve close off at maximum pump differential pressure.

2. Dampers: Size for running torque calculated as follows:
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
8. Proportional Signal: 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: Minus 22 to plus 122 degrees F.
10. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 degrees F.
11. Run Time: 60 seconds.
12. Auxiliary Switches: 2 each single-pole double throw; 7A at 250 V-AC, UL listed, one set at plus 5 degrees, one adjustable between 25 degrees and 85 degrees.

2.06 DAMPERS SEE SECTION 23 33 00, AIR DUCT ACCESSORIES

2.07 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."
PART 3 - EXECUTION

3.01 INSTALLATION

A. Verify location of thermostats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

B. Install guards on thermostats in the following locations:
   1. Entrances.
   2. Public areas.
   3. Where indicated.

C. Install automatic dampers according to Section 23 33 00, Air Duct Accessories.

D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

E. Install labels and nameplates to identify control components according to Section 23 05 53, Identification for HVAC Piping and Equipment.

F. Install refrigerant instrument wells, valves, and other accessories according to Section 23 23 00, Section Refrigerant Piping.

G. Install duct volume-control dampers according to Division 23, Heating, Ventilation, and Air Conditioning (HVA), Sections specifying air ducts.

H. Install electronic and fiber-optic cables according to Division 26 Sections.

3.02 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 26 05 33, Raceway and Boxes for Electrical Systems.

B. Install building wire and cable according to Division 26 Sections.

C. Install signal and communication cable according to Division 26 Sections.
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

F. Provide control terminals arranged as shown on building management plans.

3.03 APPLICATIONS

A. Room Temperature Sensors: Thermistor type complete with mounting bracket, blank vertical locking cover.

B. AHU-03, AHU-05, AHU-06, AHU-10, AHU-12, AHU-13 and AHU-15: Supply Duct Air Temperature Sensors: Nickel or platinum type RTD’s.

C. Pressure Transmitters/Transducers: Air-differential pressure transmitter/transducers at elevators and stairs served by AHU-01, AHU-02, AHU-04, AHU-07, AHU-09, AHU-11.

3.04 FIELD QUALITY CONTROL

A. See Section 23 08 00 Commissioning of HVAC for additional requirements. Where the same requirements are specified herein and in Section 23 08 00, request the Engineers approval to apply the requirements of Section 23 08 00 in lieu of requirements specified herein.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check instrument tubing for proper fittings, slope, material, and support.

5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

6. Check temperature instruments and material and length of sensing elements.

7. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Sound Transit’s maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

3.06 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit’s maintenance personnel to adjust, operate, and maintain Instrumentation and Control for HVAC systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
SECTION 23 09 93
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

1.01 SUMMARY

A. This Section includes control sequences for Station HVAC systems, subsystems, and equipment and operator interface requirements.

B. Sequences of Operation for Emergency Fans, Smoke Exhaust Fans and associated fan and tunnel dampers are indicated on the Contract Drawings.

C. Related Documents include Building Management System drawings.

D. All sequences controlled by the Building Management System unless otherwise indicated.

E. Related Sections include the following:
   1. Section 23 08 00, Commissioning for HVAC
   2. Section 23 09 00, Instrumentation and Control for HVAC, for control equipment and devices and for submittal requirements.
   3. Section 25 60 00, Building Management System.

1.02 DEFINITIONS

A. BMS: Building Management System

1.03 SEQUENCES OF OPERATION FOR STATION HVAC SYSTEMS:

A. Refer to Drawing N21-MH800 for control sequences of station HVAC equipment.

1.04 HUMAN MACHINE INTERFACE EQUIPMENT MONITORING:

A. See Section 25 60 00, Building Management System and Appendix A, Building Management System I/O List for monitoring and control points for each station HVAC equipment. In addition to the control points in the I/O list, indicate the following on operator workstation display terminal:

   1. BMS system graphic.
   2. BMS system on-off indication.
   3. BMS system occupied/unoccupied mode.
   5. Supply-fan on-off indication.
   6. Stairwell or Elevator static-pressure indication.
   7. Stairwell or Elevator static-pressure set point.
10. Room temperature indication.
11. Room temperature set point.
12. TPSS room 5B3-11 manual override graphic.
13. Substation room 5B3-20 manual override graphic
14. Seattle City Light room 5M-14 manual override graphic

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

3.01 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Sequence of Operation for HVAC Controls systems and equipment See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Condenser-water piping.
   2. Condensate-drain piping.

B. Related Sections include the following:
   1. Section 23 08 00, Commissioning For HVAC System.

1.02 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
   1. Condenser-Water Piping: at 150 deg F.
   2. Condensate-Drain Piping: 150 deg F.

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Action Submittals
   1. Product Data: For each type of the following:
      a. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
      b. Air control devices.
      d. Hydronic specialties.
   2. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Informational Submittals
   1. Qualification Data: For Installer.
2. Field quality-control test reports.

3. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

D. Closeout Submittals

1. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

E. Maintenance Material Submittals

1. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

2. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.04 QUALITY ASSURANCE

A. Installer Qualifications:

a. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

PART 2 - PRODUCTS

2.01 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

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

2. 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. Anvil International, Inc.

b. S. P. Fittings; a division of Star Pipe Products.

c. Victaulic Company.
3. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.

4. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

E. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. 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. T-DRILL Industries Inc.

F. Wrought-Copper Unions: ASME B16.22.

2.02 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.03 TRANSITION FITTINGS

2.04 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:
      b. Central Plastics Company.
d. Jomar International Ltd.
e. Matco-Norca, Inc.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Wilkins; a Zurn company.

2. Description:
   b. Pressure Rating: 150 psig.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   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:
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 150 psig.
   d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-join 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.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elster Perfection.
   b. Grinnell Mechanical Products.
   c. Matco-Norca, Inc.
   d. Precision Plumbing Products, Inc.
   e. Victaulic Company.

2. Description:
   a. Standard: IAPMO PS 66
   b. Electroplated steel nipple. complying with ASTM F 1545.
   c. Pressure Rating: 300 psig at 225 deg F.
   d. End Connections: Male threaded or grooved.
   e. Lining: Inert and noncorrosive, propylene.

2.05 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23, General-Duty Valves for HVAC Piping.

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 00, Instrumentation and Control for HVAC.

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
f. Taco.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.

4. Plug: Resin.

5. Seat: PTFE.

6. End Connections: Threaded or socket.


8. Handle Style: Lever, with memory stop to retain set position.


10. Maximum Operating Temperature: 250 deg F.

D. Diaphragm-Operated, Pressure-Reducing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.

3. Disc: Glass and carbon-filled PTFE.


5. Stem Seals: EPDM O-rings.

6. Diaphragm: EPT.

7. Low inlet-pressure check valve.

8. Inlet Strainer: removable without system shutdown.


10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Diaphragm-Operated Safety Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.

3. Disc: Glass and carbon-filled PTFE.


5. Stem Seals: EPDM O-rings.

6. Diaphragm: EPT.


8. Inlet Strainer: removable without system shutdown.


10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. low Design Inc.
   b. Griswold Controls.

2. Body: Brass or ferrous metal.

3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.

4. Combination Assemblies: Include bronze or brass-alloy ball valve.

5. Identification Tag: Marked with zone identification, valve number, and flow rate.

6. Size: Same as pipe in which installed.

7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.

9. Maximum Operating Temperature: 200 deg F.

2.06 AIR CONTROL DEVICES

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
4. Inlet Connection: NPS 1/2.
7. Maximum Operating Temperature: 240 deg F.

D. Diaphragm-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
E. Tangential-Type Air Separators:
   1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
   2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
   3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
   5. Size: Match system flow capacity.

F. In-Line Air Separators:
   1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
   3. Maximum Operating Temperature: Up to 300 deg F.

G. Air Purgers:
   1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
   3. Maximum Operating Temperature: 250 deg F.

2.07 CHEMICAL TREATMENT

A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
   1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

B. Ethylene and Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

2.08 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
B. Basket Strainers:
   1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

C. 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.

D. Stainless-Steel Bellow, Flexible Connectors:
   2. End Connections: Threaded or flanged to match equipment connected.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

E. Spherical, Rubber, Flexible Connectors:
   2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

   A. Condenser-water piping, aboveground, NPS 2 and smaller:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

B. Condenser-water piping, aboveground, NPS 2-1/2 and larger:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

C. Condenser-water piping installed belowground and within slabs:
   1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered brazed joints. Use the fewest possible joints.

D. Glycol cooling-water piping, aboveground, NPS 2 and smaller:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

E. Glycol cooling-water piping, aboveground, NPS 2-1/2 and larger:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Glycol cooling-water piping installed belowground and within slabs:
   1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered brazed joints. Use the fewest possible joints.

G. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

3.02 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 23 05 23, General-Duty Valves for HVAC Piping.

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Identify piping as specified in Section 23 05 53, Identification for HVAC Piping and Equipment.
U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17, Sleeves and Sleeve Seals for HVAC Piping.

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17, Sleeves and Sleeve Seals for HVAC Piping.

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18, Escutcheons for HVAC Piping.

3.04 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment. Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment.

C. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.05 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

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


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

G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

H. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

I. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.06 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

F. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.

2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
3.07 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

3.08 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.

3. Isolate expansion tanks and determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system’s working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times “SE” value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Prepare written report of testing.
C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.09 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Hydronic Piping systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1. Section 23 08 00, Commissioning For HVAC System.

1.02 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.03 REFERENCES

A. American Society of Mechanical Engineers (ASME)

1. Boiler and Pressure Vessel Code (BPVC), Section IX, Welding and Brazing Qualifications

2. B31.5 Refrigeration Piping and Heat Transfer Components

3. B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

4. B16.5 Pipe Flanges and Flanged Fittings

5. B1.20.2 Pipe Threads, General Purpose (inch)

6. B31.5 Power Piping and Process Piping SET

B. American Society for Testing and Materials International (ASTM)

1. ASTM B280 Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

2. ASTM B 32 Solder Metal

3. ASTM A 53/53M Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

4. ASTM A 234/234M Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

5. ASTM B828 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

C. Manufacturers Standardization Society for the Valve and Fittings Industry

1. MSS SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
D. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
   1. ASHRAE 15 Safety Standards for Refrigeration Systems
   2. ASHRAE 34 Designation and Safety Classification of Refrigerants

E. American Welding Society (AWS)
   1. AWS 5.8 Filler Metals for Brazing and Braze Welding

F. The Air-Conditioning and Refrigeration Institute (ARI)
   1. ARI 760 Solenoid Valves for Use with Volatile Refrigerators
   2. ARI 750 Thermostatic Refrigeration Expansion Valves
   3. ARI 730 Flow-Capacity Rating and Application of Suction-Line Filters and Driers
   4. ARI 495 Refrigerant Liquid Receivers

1.04 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-22:
   3. Hot-Gas and Liquid Lines: 325 psig.

B. Line Test Pressure for Refrigerant R-134a:

C. Line Test Pressure for Refrigerant R-407C:

D. Line Test Pressure for Refrigerant R-410A:
1.05 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. Refrigerant piping indicated on Shop Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."


C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.07 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.08 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00, Roof Accessories.
PART 2 - PRODUCTS

2.01 COPPER TUBE AND FITTINGS
A. Copper Tube: ASTM B 280, Type ACR.
B. Wrought-Copper Fittings: ASME B16.22.
C. Wrought-Copper Unions: ASME B16.22.
D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
E. Brazing Filler Metals: AWS A5.8.
F. Flexible Connectors:
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
   5. Maximum Operating Temperature: 250 degrees F.

2.02 STEEL PIPE AND FITTINGS
A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.
B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.
E. Flanged Unions:
   1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
   2. Gasket: Fiber asbestos free.
   3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
   4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
   5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.

7. Maximum Operating Temperature: 330 degrees F.

F. Flexible Connectors:


2. End Connections:
   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.


5. Maximum Operating Temperature: 250 degrees F.

2.03 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.


3. Operator: Rising stem and hand wheel.


5. End Connections: Socket, union, or flanged.


7. Maximum Operating Temperature: 275 degrees F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.

2. Packing: Molded stem, back seating, and replaceable under pressure.

3. Operator: Rising stem.


5. Seal Cap: Forged-brass or valox hex cap.

6. End Connections: Socket, union, threaded, or flanged.


8. Maximum Operating Temperature: 275 degrees F.
C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
9. Maximum Operating Temperature: 275 degrees F.

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24 OR115-V ac coil.
7. Maximum Operating Temperature: 240 degrees F.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.
6. Maximum Operating Temperature: 240 degrees F.

G. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 degrees F.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24 or 115-V ac coil.
9. Set Pressure: as manufacture recommends
10. Throttling Range: Maximum 5 psig.
12. Maximum Operating Temperature: 240 degrees F.

I. Straight-Type Strainers:
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
5. Maximum Operating Temperature: 275 degrees F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 degrees F.

K. Moisture/Liquid Indicators:
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 degrees F.

L. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
8. Rated Flow: as required by manufacture
10. Maximum Operating Temperature: 240 degrees F.

M. Permanent Filter Dryers: Comply with ARI 730.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
8. Rated Flow: as required by manufacture
10. Maximum Operating Temperature: 240 degrees F.

N. Mufflers:
2. End Connections: Socket or flare.
4. Maximum Operating Temperature: 275 degrees F.

O. Receivers: Comply with ARI 495.
1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
7. Maximum Operating Temperature: 275 degrees F.

P. Liquid Accumulators: Comply with ARI 495.
2. End Connections: Socket or threaded.
4. Maximum Operating Temperature: 275 degrees F.
2.04 REFRIGERANTS

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

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-22: Monochlorodifluoromethane.
D. ASHRAE 34, R-134a: Tetrafluoroethane.
E. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
F. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-22

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping:
1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.02 PIPING APPLICATIONS FOR REFRIGERANT R-134A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping:
   1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.03 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 1 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
   2. NPS 1-1/4 to NPS 2: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping:
   1. NPS 1 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
   2. NPS 1 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or solderedjoints.
   3. NPS 1-1/4 to NPS 2: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.04 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 5/8 and Smaller: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3. NPS 1-1/4 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

H. Safety-Relief-Valve Discharge Piping:

1. NPS 5/8 and Smaller: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3. NPS 1-1/4 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

4. NPS 1-1/2 to NPS 2: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

3.05 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.06 PIPING INSTALLATION

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

B. Install refrigerant piping according to ASHRAE 15.

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

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

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.
I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 23 09 00, Instrumentation and Control for HVAC, and Section 23 09 93, "Sequence of Operation for HVAC Controls," for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 00, Access Doors and Panels, if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician’s tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
S. Seal penetrations through fire and smoke barriers according to Section 07 84 00 Firestopping.

T. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

U. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

V. Seal pipe penetrations through exterior walls according to Division 07 Section 07 92 00, Joint Sealants, for materials and methods.

W. Identify refrigerant piping and valves according to Section 23 05 53, Identification for HVAC Piping and Equipment.

3.07 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and 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. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

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

A. Hanger, support, and anchor products are specified in Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.

E. Support multifloor vertical runs at least at each floor.

3.09 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.10 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line.

3.11 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.
3.12 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Refrigerant Piping systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. The work specified in this section includes furnishing, installing, connecting and testing following equipment for tunnel ventilation and smoke exhaust systems.

1. Emergency fans
2. Smoke exhaust fans
3. Fan motors
4. Fan motor auxiliaries
5. Interconnecting power and control wiring
6. Fan dampers, tunnel dampers and controls
7. Sound attenuators
8. Local instrument panels
9. Miscellaneous appurtenances

B. The Work includes the following:

1. Furnishing, testing, and installing tunnel ventilation equipment identified as emergency or tunnel ventilation fans, smoke exhaust fans, dampers, sound attenuators and associated appurtenances for complete operating tunnel ventilation system. All work shall comply with NFPA 130 and shall be in accordance with local codes. If necessary, fans shall be installed in sections to accommodate transfer to fan room.

C. The Work also includes the following:

1. Submitting for approval working drawings indicating the size and location of each concrete foundation for the axial fans, reinforcing bar requirements for these foundations and the expected static and dynamic forces and moments generated by the equipment.

2. Furnishing and installing reinforcing bars, dowels and concrete required for the construction of the equipment foundations.

3. Furnishing and installing anchor bolts and anchor bolt details indicating the type, size and location of anchor bolts required for the installation of the fans and accessories, dampers and ductwork.

4. Submitting for approval terminal-to-terminal working drawings of the electrical power and control interconnections between equipment supplied by this
Contractor; power and control interconnections to each damper motor; control connections to interface terminal cabinets.

5. Furnishing and installing all the metal ductwork connecting the fan and its accessories, including the ductwork between the fan accessories and the building structure.

6. Furnishing and installing companion flanges and mounting frames shown on Contract drawings. Coordinating hole locations and hole sizes on companion flanges and mounting frames with connecting damper flanges, sound attenuators flanges, ductwork flanges and screen guards.

7. Designing, furnishing and installing of equipment and ductwork supports.

D. The following definitions apply to the Work of this Section:

1. Fan: The terms fan, emergency fan, tunnel ventilation fan, smoke exhaust fan, and fan assembly are synonymous and are deemed to be a axial flow fan complete with flexible connections, sound attenuators, transition pieces, directly connected reversible or non-reversible motor as appropriate and mounting brackets as required. (Exception: Station smoke exhaust fans shall be intended to operate in forward direction only with non-reversible motors and directional vanes as required, while the emergency fans shall be reversible.)

2. Forward Flow: Airflow generated by the fan in the direction of the fan impeller toward the fan motor. Forward direction of airflow shall be in exhaust mode; exhausting air from tunnels to atmosphere.

3. Reverse Flow: Airflow generated by the fan in the direction of the fan motor toward the fan impeller. Reverse direction of airflow shall be in supply mode; supplying air from atmosphere to tunnels.

4. Pitch: The angle formed by the chord line of a fan blade root cross-section and a line parallel to the direction of rotation.

5. Manufacturer’s Representative: A representative from the firm of manufacturer for each and every category of equipment furnished under this Section.

E. Fan Manufacturer

1. The manufacturer of the fans provided under these Contract Specifications shall be a manufacturer who, for at least 5 years, has been regularly engaged in the design, assembly and testing of axial flow fans of the type and capacity not less than that to be furnished under this Contract, and have experience in the design and fabrication of fans capable of operation at 482 degrees F air stream for one hour.

2. All fans provided under this Contract shall be the product of the same manufacturer whose name appears on the theoretical fan performance curves submitted in accordance with Article 1.04.C.1, Submittals – Products Data, herein.

F. Related Sections: The work of following Contract Specification sections is related to the work of this Section.

1. Section 01 46 01, System Assurance – Emergency Ventilation Equipment

2. Section 23 08 00, Commissioning of HVAC Systems
3. Section 25 08 00, Commissioning of Integrated Automation

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

B. Air Movement and Control Association (AMCA):
   1. 210 Laboratory Methods of Testing Fans for Certified Aerodynamics Performance Rating (ASHRAE 51)
   2. 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   3. 500D Laboratory Methods of Testing for Dampers Ratings

C. American Bearing Manufacturers Association (ABMA):
   1. 9 Load Ratings and Fatigue Life for Ball Bearings
   2. 11 Load Ratings and Fatigue Life for Roller Bearings

D. American Institute of Steel Construction, Inc. (AISC):
   1. Steel Construction Manual

E. American Iron and Steel Institute (AISI)

F. American National Standards Institute (ANSI):
   1. B46.1 Surface Texture, Surface Roughness, Waviness and Lay, Part 1
   2. C1 Specification of General Requirements for a Quality Program
   3. S12.56 Determination of Sound Power Levels of Noise Sources
   4. S2.19 Balance Quality Requirements of Rigid Motors

G. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
   1. 51 Laboratory Method of Testing Fans for Rating
   2. ASHRAE Handbook – Fundamentals

H. American Society of Mechanical Engineers (ASME)
   1. B18.21.1 Lock Washers

I. American Society for Non-Destructive Testing (ASNT)

J. American Society for Testing and Materials International (ASTM)
   1. ASTM A36 Structural Steel
   2. ASTM A123 Zinc (Hot-Dip-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Castings, Plates, Bars, and Strip
3. ASTM A193 Alloy--Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications
4. ASTM A194 Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
5. ASTM A239 Locating Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles
6. ASTM A240 Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
7. ASTM A276 Stainless and Heat-Resisting Steel Bars and Shapes
8. ASTM A388 Practice for Ultrasonic Examination of Heavy Steel Forgings
9. ASTM A588 High Strength Low Alloy Structural Steel
10. ASTM A666 Annealed or Cold Worked Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar for Structural Applications
11. ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus
12. ASTM B247 Aluminum and Aluminum-Alloy Die, Hand and Rolled Ring Forgings

K. American Welding Society (AWS):
   1. AWS D1.1 Structural Welding Code, Steel
   2. AWS D1.3 Structural Welding Code, Sheet Steel
   3. AWS D14.6 Welding of Rotating Elements of Equipment

L. International Building Code (IBC)

M. Insulated Cable Engineers Association (ICEA)

N. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 112 Standard Test Procedure for Polyphase Induction Motors and Generators

O. National Electrical Manufacturers Association (NEMA):
   1. NEMA ICS Industrial Controls and Systems
   2. NEMA ICS 2 Industrial Controls Devices, Controllers and Assemblies
   3. NEMA MG1 Motors and Generators

P. National Fire Protection Association (NFPA):
   1. NFPA 91 Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particle Solids
   2. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems
3. NFPA 221 Fire Walls and Fire Barrier Walls
4. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials (UL 723)

Q. Steel Structures Painting Council (SSPC):
   1. SP-3 Power Tool Cleaning
   2. SP-6 Commercial Blast Cleaning
   3. PA-1 Shop, Field, and Maintenance and Painting
   4. PA-2 Method for Measurement of Dry Film Thickness with Magnetic Gages

R. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
   1. SMACNA Industrial Duct Construction Standards

S. Underwriters Laboratories (UL)
   1. UL 508 Industrial Control Equipment

1.03 GENERAL REQUIREMENTS

A. Design Criteria:
   1. Fans, attenuators and motorized dampers are a critical component of the tunnel emergency ventilation system and smoke exhaust system. The requirements given herein are designed to ensure that the equipment will function when needed.
   2. The ventilation equipment shall be designed for a transit subway environment. Unusual aspects of this environment include the following:
      a. Dust and dirt from steel wheel and brake wear.
      b. Transient pressure fluctuations from high speed train operations in a subway.
      c. Exposure to combustion products and high temperature air from a fire emergency.
   3. Exposure to air at ambient temperatures and humidity.
      a. Specific criteria values unless otherwise indicated:
      b. Design high temperature: 482 degrees F
      c. Design low temperature: 24 degrees F

B. Seismic Criteria:
   1. In accordance with IBC.
      a. Occupancy Category: IV
      b. Site Class: C
c. $S_s(g): 1.4$

d. $S_1(g): 0.48$

C. Clearance Limitations

1. The Contract Drawings indicate the fan room in which the emergency fans, smoke exhaust fans, sound attenuators and accessories shall be installed and the clearances of openings and passages through which the components shall be moved for installation and removal in the future. These dimensions shall be field verified by the Contractor.

2. The emergency fans, smoke exhaust fans, sound attenuators and accessories shall be provided of such size and arrangement that they will pass through the openings and passages available for the purpose. The Contractor shall provide supports and bracing as required during handling and erection.

3. Equipment and ductwork supports shall be such that equipment and ductwork can be removed without cutting of supports.

D. Handling of Materials

1. The Contractor shall be responsible for all damage caused to the structure in the lifting and transferring operations, at no increase in Contract Price or Contract Time.

E. Supervision of Tunnel Ventilation Equipment Installation

1. The Contractor shall provide the services of a qualified erection superintendent who is competent and experienced with the work involved in the installation of ventilation equipment of this type. The erection superintendent shall, at the site, supervise emergency fan and accessory installation and shall be available when the work in connection with the above ventilation equipment installation is proceeding to verify that the work is properly performed.

F. Welding: All components in this Contract requiring welding shall be welded as follows:

1. Code Requirement: Welding shall conform to the requirements of AWS D1.1 and AWS D1.3, and AWS D14.6 as applicable.

2. Welder Qualification: Welders welding on the work of this project shall be qualified in accordance with the requirements of AWS D1.1, Section 5, Qualification.

3. Process: The welding process employed on the work of this project shall be the shielded metal arc process, in accordance with AWS D1.1 and AWS D14.6 as applicable.

4. Welds shall be inspected with non-destructive testing (NDT). Person performing non-destructive testing shall be certified by ASNT. Only personnel certified for NDT Level I and working under or NDT Level II person or persons certified for NDT Level II may perform non-destructive testing.

G. Spare Parts

1. Provide list of recommended spare parts and tool list for fans, dampers and sound attenuators for Sound Transit’s approval.
2. Provide spare parts and tools according to spare parts list and tool list.

3. Provide one spare impeller hub and one complete set of spare blades for each type and size of the fan. Store spare hub and blades in secure storage containers with permanent labels identifying size of the fan, manufacturers and Sound Transit’s Contract Number.

4. Provide one spare motor identical to the motors supplied for each type and size of the motor. Store spare motor in secure storage containers with permanent labels identifying size of the motor, size of associated fan, manufacturers and Sound Transit’s Contract number.

5. Provide any proprietary tool required for maintenance and/or repair or programming operation.

H. Project record documents requirements shall be according to Section 01 78 39, Project Record Documents.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Shop Drawings: Submit fabrication, assembly, erection, and installation drawings. Indicate descriptions, details, dimensions, arrangements, and assemblies, and locations of all fans, housings, sound attenuators, dampers and ductwork. Include foundation and anchorage data.

1. Submit dimensioned drawings of the fans showing duct transitions, sound attenuator assembly layout, supports, and other appurtenances required for installation. Show on shop drawings, point loads at each support point including summary of dead loads, live loads, axial loads, thrust loads, clearance between the fan and structure, and complete installation details. Design the fan supports in accordance with the design criteria in Article 1.03, General Requirements, herein.

2. Submit structural support design calculations, certified by a professional engineer registered in the state of jurisdiction.

3. Submit theoretical motor performance curves, which are either derived from actual performance tests or from analytical data.

4. Submit shop drawings and the test procedures for the pre-production units as a package.

5. Submit shop drawings for dampers.


C. Product Data: Submit manufacturer’s product data and certified test reports for each fan, including fan performance curves, sound power ratings, and electrical characteristics.

1. Submit fan performance curves, separate for forward and reverse direction, initially for each type of fan, and finally for fans as part of the manufacturer’s fan certification test results. Performance curves for the initial submittal shall be derived from fan model investigation or actual tests and shall be considered reasonably predictive of the actual fan performance. Fan performance curves shall have the following data plotted as ordinates versus cubic feet per minute as abscissa:
a. Total pressure, inches of water.
b. Static pressure, inches of water.
c. Static efficiency, percentages.
d. Total efficiency, percentages.
e. Horsepower input to fan.
f. Kilowatt input to the motor.

2. The following information shall be included with each performance curve:
   a. Project title.
   b. Name of motor manufacturer.
   c. Catalog name and number of motor.
   d. Direction of rotation of motor.
   e. Speed, rpm.
   f. Electrical characteristics.
   g. Fan housing diameter.
   h. Hub diameter and hub pocket dimension.
   i. Number of blades, blade length and blade weight.
   j. Fan blade boss dimension.

3. Submit product data for dampers, including frames, blades, linkages, operators, and damper leakage certified data.

4. Submit product data for sound attenuators including housing, Bill of Material and construction.

5. Submit factory and field test procedures for all fans.

6. Submit factory and field test procedures for all dampers.

D. Records and Certificates: Submit certified test reports of the results of all factory tests and field tests for all fans as specified herein; Part 3 - Execution. Include all records and results of impeller assembly tests.

E. Operations and Maintenance Data: Submit manufacturer's operation and maintenance data and instructions, troubleshooting, corrective maintenance for the fan, test criteria and standards, including fan-motor unit disassembly and reassembly instructions in an Operation and Maintenance Manual. Include spare parts and special tools lists, CAD Drawings and Bills of Material for fan, motor, damper and sound attenuator. Operation and Maintenance Data shall be according to Article 1.04.M, Operation and Maintenance Manual, herein.

F. Test Procedures and Reports:
1. Full details shall be submitted of the scheduled tests and the expected duration of all tests. Samples of all test report forms, details of the methods by which the raw test data is to be reduced and expected test results shall be submitted for review and approval before testing can begin on ventilation equipment, furnished under this Contract. No proprietary information is required to be submitted under this Contract.

2. The test report shall identify the name of manufacturer, model numbers, serial numbers, and the last date of calibration of test instrumentation. Documentation shall be furnished to verify that test instruments have been calibrated not more than 6 months prior to the tests.

3. The test report shall include a list of attendees.

4. Certified test results for all fan, motor, sound attenuator, and damper tests shall be submitted within 30 days after the completion of each test. No equipment shall be released for shipment until the acceptance of certified test data. Copies of accepted test procedures, raw data measured results, calculations and all data derived from tests shall be included as part of report. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner. No proprietary information is required to be submitted under this contract.

5. Submit actual performance curves after completion of the fan shop tests and fan motor shop tests.

6. Test points shall be indicated on performance curves.

7. All performance curves shall be plotted to such scales as will make it possible to read the data accurately.

8. The performance curves shall be plotted on graph sheets not less than 8-1/2 inches by 11 inches in size.

9. The report shall contain all the results and conclusions and shall include all performance curves, tables, and data required by Article 1.07, Factory Tests and Inspections.

G. Axial Fans:

1. Fan Theoretical Performance Curves:
   a. Submit for each size fan (listed in the equipment schedule of Contract Drawings), theoretical fan performance curves as specified below. The performance curves shall cover the entire range of load conditions from free delivery to no delivery at 5-degree increments of blade angle above and below the proposed design blade angle. For emergency fans separate curves shall be furnished for forward and reverse direction and each curve shall be identified accordingly.
   b. Plot the following composite theoretical fan performance curves with abscissas as air volume in cubic feet per minute and ordinates as:
      1) Fan total pressure in inches of water.
      2) Fan static pressure in inches of water.
      3) Static efficiency in percent.
4) Total efficiency in percent.

5) Horsepower input to fan shaft.

c. The system resistance curve shall be plotted on each fan curve for two fan parallel operations as required.

d. The stated performance data for both the forward (exhaust) and the reverse (supply) modes shall be based on the fans operating in parallel in each mode, forward (exhaust) and reverse (supply). On each performance curve sheet following information shall be stated:

1) Name of fan manufacturer.

2) Name of motor manufacturer.

3) Fan model number.

4) Contract designation number.

5) Number of fans operating in parallel.

6) Fan operating speed in revolutions per minute.

7) Volume of air delivered in cubic feet per minute.

8) Fan total pressure in inches of water.

9) Fan static pressure in inches of water.

10) Fan outlet velocity in feet per minute.

11) Fan outlet velocity pressure in inches of water.

12) Fan static efficiency in percent.

13) Fan total efficiency in percent.

14) Horsepower input to fan shaft.

15) Air density in pounds per cubic foot. (Performance shall be published for an air density of 0.082 lb. /per cubic feet.)

16) Fan hub diameter in inches.

17) Fan housing inside diameter in inches.

18) Fan outlet area in square feet.

19) Number of fan blades.

20) Blade angle setting.

21) Direction of airflow (forward or reverse)

22) Calculated rotational moment of inertia of fan wheel assembly in pounds-feet squared.
23) Acceleration time from standstill to operating speed for each mode of operation, supply and exhaust.

24) Maximum motor amperage to start fan from rest.

2. Submit estimated sound power level in decibels (re: db 10-12 watts) of the fan(s) at the design duty point(s) at the eight octave band center frequencies from 63 Hertz to 8,000 Hertz for both forward and reverse directions.

3. Submit documentation by the manufacturer that they have at least five years of continuous and current experience in transit industry in the design, assembly and testing of axial flow fans of the type and capacity not less than that to be furnished under this Contract, and have experience in the design and fabrication of fans capable of operation without failure at 482 degree Fahrenheit air stream for one hour.

4. List of components to be purchased from other manufacturers, giving name of manufacturer, type and characteristic of each item.

5. Certificate of Compliance signifying that equipment to be furnished under this Contract meets the requirements specified herein.

6. Shop Drawings for fans, motors, fan-motor unit bases, installation drawings, dimensioned drawings for anchor bolt locations, and all additional data required to demonstrate compliance with Contract documents.

7. Actual Fan Performance and Noise Data: After completion of the fan shop performance tests, submit for each of the three design duty points, described in Article 1.04.G.1.a, Axial Fans, herein, performance curves and tables of performance data calculated from factory test data taken at each of the test points for both the exhaust (forward) and supply (reverse) modes. The tables shall consist of numerical values at each of the test points for the following:

   a. Volume of air delivery in cubic feet per minute.
   b. Fan total pressure in inches of water.
   c. Fan static pressure in inches of water.
   d. Fan outlet velocity pressure in inches of water (with reference to both the fan discharge area and the diffuser discharge areas).
   e. Fan static efficiency in percent.
   f. Fan total efficiency in percent.
   g. Horse power input to fan shaft.
   h. Fan operating speed in revolutions per minute.
   i. Air density in pounds per cubic feet.
   j. Voltage, current, KW input and power factor of motor.
   k. Sound power readings for each of eight octave bands taken in accordance with ANSI S12.56.
1) Note: All data shall be reduced to an air density of 0.082 lb. /cubic foot.

8. Actual Performance Curves: Submit, after completion of performance tests, performance curves comparable in every respect to the fan theoretical performance curves, as defined above.

9. All records and results of non-destructive examinations.

10. Working Drawings:
   a. Pre-production Fan:
      1) Submit (non-proprietary) working (layout) drawings for the pre-production unit. Show and fully dimension details of all components.
      2) Submit revised working drawings indicating changes to the pre-production fan unit if initial prototype fan shop tests are unsatisfactory, prior to repeating the fan shop tests.
   b. Production Fan Unit(s):
      1) Submit (non-proprietary) working drawings for the full size fans and accessories.
      2) Show and fully dimension details of all components including the following:
         a) General arrangement drawing showing fan unit fully assembled.
         b) Fan housings showing maintenance and assembly.
         c) Inlet and outlet transitional ducts.
         d) Straightening vane details.
         e) Inlet screens, indicate net free area.
         f) Fan rotor and blade assembly.
         g) Fan isolation base.
         h) Fan bearings.
         i) Anchor bolts.
         j) Motor and motor enclosure.
         k) Fan nameplates.
         l) Fan number plates.
         m) Flexible connectors.
         n) Submit data on fan bearing lubricant.
         o) Concrete foundations.
3) Indicate the weight of each removable maintenance section, removable half of the fan housing, the motor, each fan wheel assembly, each inlet and outlet diffuser and the entire weight of the assembled fan.

4) Indicate the size, length, spacing and type of welds.

5) Detail non proprietary working (layout) drawings in accordance with the requirements of the following AISC Publication:
   a) Steel Construction Manual.

6) Show the size and location of holes for bolting the fan housing to the isolation base anchor bolts.

7) Indicate for the fan/motor unit vibration amplitudes, unbalanced radial forces and thrust forces at each motor bearing.

H. Fan Motors:

1. Theoretical Fan Motor Performance Curves:
   a. Submit theoretical fan motor performance curves at rated voltage and speed as specified below.
   b. The fan motor performance curves shall be as follows:
      1) Composite curve plotted with abscissas as horsepower output from no load up to 125 percent full load and ordinates as:
         a) Current in amperes.
         b) Efficiency in percent.
         c) Power factor in percent.
      2) Composite curve plotted with abscissas as speed in revolutions per minute from standstill to the synchronous speed of motor and ordinates as:
         a) Motor current in amperes.
         b) Motor torque in pound-feet.
         c) Power factor in percent.
         d) Fan input torque in pound-feet.
      3) Temperature Test: Time in minutes as abscissa versus temperature rise in degrees Fahrenheit as ordinates when operated at full voltage and speed.
      4) Insulation Resistance - Temperature Load Test. Test result values shall be plotted on semi-logarithmic graphs, the insulation resistance values as logarithmic ordinates and the temperature values as uniform abscissa.
      5) Also, for comparison purposes, a curve indicating the safe operating value of insulation resistance shall be plotted on the
same sheet with the insulation resistance-temperature test curve.

6) On each theoretical fan motor performance curve sheet shall be stated the following information:
   a) Project title.
   b) Name and address of Contractor.
   c) Fan designation number.
   d) Name and address of motor manufacturer.
   e) Motor type.
   f) Motor number designation
   g) Motor frame size
   h) Motor nameplate horsepower rating.
   i) Nameplate voltage rating.
   j) Nameplate frequency rating and phase.
   k) Full and no load current.
   l) Locked rotor current
   m) Motor torque in pound-feet including locked rotor torque, pull-up and breakdown torque
   n) Motor synchronous speed in revolutions per minute.
   o) Motor maximum safe operating speed in revolutions per minute.
   p) Service factor.
   q) Calculated rotational moment inertia of motor rotor in pounds-feet squared.
   r) Calculated rotational moment of inertia of fan wheel assembly in pounds-feet squared.
   s) Maximum allowed motor starting time to accelerate fan wheel from rest to its operating speed, with damper fully open.


3. Submit shop drawings for fan motors

4. Working (layout) Drawings:
   a. Submit non-proprietary working (layout) drawings for fan motors.
b. Show and fully dimension details of all components including the following:

1) Motor frames.
2) Motor end brackets.
3) Motor space heaters.
4) Motor leads.
5) Motor conduit and junction boxes.
6) Motor shafts.
7) Motor bearings, including certified bearing analysis from the bearing manufacturer for each different bearing used.
8) Motor nameplates.
9) Weight of each motor.
10) Submit data on fan motor bearing lubricant.
11) Motor bearing vibration sensors.
12) Motor speed sensors/switches.
13) Motor power and control terminal boxes.

5. Factory Tests: Submit at completion of factory motor testing six certified copies of test results.

I. Fan Dampers and Tunnel Dampers (Parallel Blade):

1. Damper Performance Data: Submit certified performance curves and calculated data. All data shall be based on an air density of 0.082 pound per cubic foot.

   a. Curve plotted with abscissas as approach velocity in feet per minute and ordinate as pressure drop in inches water gauge for damper in the wide open position.

   b. Calculated data indicating the air leakage in cubic feet per minute through damper in the closed position against a pressure differential of from zero through 10 inches of water gauge. Curve plotted with abscissas as pressure differential in inches water and ordinate as the air leakage in cubic feet per minute.

   c. Contractor shall submit certified calculated data determining the torque required to operate the damper under specified air flow in the open position and at the specified pressure differential in the closed position.

   d. On each test data sheet the following shall be stated:

      1) Project Title
      2) Name and address of Contractor.
      3) Name and address of damper manufacturer.
4) Damper designation number.
5) Corresponding fan designation numbers.
6) Air density in pound per cubic foot.
7) Damper face area in feet squared.
8) Damper free area ratio in percent.
9) Number of modules and configuration.
10) Actuators and jack shaft details.
11) Wiring Diagram, power requirements and limit switches.

e. The information above shall be based upon data developed in a shop test(s) on a geometrically similar damper(s) tested in accordance with AMCA 500D.

2. Working Drawings:
   a. Submit (non-proprietary) working drawings for dampers.
   b. Show and fully dimension details of all components including the following:
      1) Frames.
      2) Blades.
      3) Shafts.
      4) Linkages.
      5) Cranks.
      6) Stops.
      7) Limit switches.
      8) Bearings.
      9) Blade edge and jamb seals.
     10) Operator Motor and speed reducer.
     11) Damper operator support base.
     12) Operator Motor and speed reducer nameplates including motor voltage, horsepower, locked rotor amperes, full load amperes, power factor, service factor, phases and frequency.
     13) Weight of each damper assembly unit including support legs where applicable.
     14) Damper terminal box locations and details.
c. Submit data on lubricant for damper shaft bearings, motor bearings and speed reducers.

d. Submit damper operator and electrical control interconnection drawings.

e. The damper operator manufacturer shall certify in writing that the operator and all the internal components are suitable under the ambient temperature range specified herein.

J. Sound Attenuators

1. Performance test procedures shall be submitted at least two weeks prior to the shop test on the scale model.

   a. Procedure shall show conformance to the requirements of ASTM E477 and shall include a fully dimensioned drawing of the model attenuator.

   b. The procedure shall include theoretical or estimated performance data for dynamic insertion loss, self-noise characteristics and air pressure loss with design airflow in both directions.

   c. A detailed description of the instrumentation and measurement techniques shall be submitted with the procedures.

   d. Upon completion of testing, submit a report that includes the procedures, all raw data, and the results. All the results shall be corrected and presented for an air density of 0.082 pound per cubic foot.

2. Working Drawings

   a. Submit (non-proprietary) working drawings for each unique sound attenuator.

   b. Working drawings shall include fully dimensioned details of all components including the following:

      1) Overall attenuator dimensions.

      2) Reinforcing angles.

      3) Gage thickness of all sheet metal and plate components.

      4) Internal baffle width and spacing.

      5) Connection flanges including bolt hole sizes and spacing.

      6) Weldment details.

      7) Details of supporting legs for floor mounting.

      8) Details of lifting lugs.

      9) Actual performance data of dynamic insertion loss in each of 8 octave bands and pressure loss data.

         a) The performance information shall be presented on the shop drawing, at an air density of 0.082 pound per cubic foot and for design air flows in both forward (exhaust) and reverse (supply) directions.
K. Painting Submittals:

1. Application Instructions: Surface preparation, primer, intermediate and top coat shall be applied in accordance with the requirements of the paint manufacturer's printed paint application instructions. A copy of these instructions shall be submitted.

2. Paint Samples:
   a. Submit four samples of the specified surface preparation, primer, intermediate and topcoat paint coats applied together on a blast cleaned steel sheet. The paint coats shall be applied shingle fashion to expose each representative coat.
   b. The samples shall be 12 inches square and shall be marked with manufacturer's type and color designation.

L. Certificate of Compliance: A certificate of compliance that all components furnished meet the requirements specified herein shall be submitted.

M. Operation and Maintenance Manual:

1. Provide according to Section 01 78 23, Operation and Maintenance Data.

2. The Contractor shall furnish an operation and maintenance manual containing information for each piece of equipment. The following identification shall be inscribed on the cover: the words "OPERATING AND MAINTENANCE MANUAL TUNNEL VENTILATION EQUIPMENT", the name and location of the project, the name of the Contractor, and the Contract number. The manual shall include the names, addresses, and telephone numbers of each Subcontractor furnishing or installing equipment and of the local representatives for each item of equipment. The manual shall have a table of contents and be assembled to conform to the table of contents. The pages shall be legible with large sheets of drawings folded in.

3. The manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring and mechanical assembly diagrams, as required. The manual shall be indexed and cross-referenced in an easily understood manner. The manual shall be loose leaf bound and shall include, but not necessarily be limited to, the following information:
   a. Operating instructions.
   b. Troubleshooting and fault isolation procedures for on-site level repair.
   c. A written procedure for airflow measuring in the field with pitot tube and manometer.
   d. Procedures for separately removing and replacing motor, rotor, and blades.
   e. Fan removal and replacement procedures.
   f. Disassembly and reassembly instructions.
g. A list of the components that are replaceable at the three possible levels of maintenance: on site, Sound Transit’s shop, and the manufacturer’s facility.

h. A test procedure to verify the adequacy of repair work on the fans.

i. A preventive maintenance schedule and instructions for the replacement of all electrical component requiring periodic replacement, and detailed instructions for lubrication of moving parts and monitoring of vibration levels.

j. A preventive maintenance schedule for motor bearing inspection, removal and replacement for each component.

k. A list of parts to be replaced and or testing procedures to determine parts to be replaced after a fan has been exposed to a fire emergency condition with air temperatures through the fan exceeding 482 degrees F. This is intended to allow the fan to be put back in service safely and reliably.

l. A list of special tools provided by the manufacturer.

m. A list of recommended tools and test equipment required to perform all maintenance tasks.

n. Two heavy gauge Mylar templates for each fan, for blade angle setting in the field. Template shall include design, maximum, intermediate and minimum blade angles.

o. Recommended spare parts list for one year’s operation.

p. Interchangeable parts list showing parts common to items of equipment.

q. Equipment manufacturers’ descriptive literature including catalog cuts.

r. Record working drawings.

s. Fan, sound attenuator and damper factory test reports.

t. The latest service bulletins with dates that describe the fan, motor and damper operator manufacturer’s service procedures.

1.05 QUALITY CONTROL

A. Quality control requirements shall be according to Section 01 45 00, Quality Control.

B. Manufacturer’s quality assurance program shall be in accordance with ANSI C1.

C. Training: The Contractor shall make available the services of the manufacturer’s service representative for a period of two 8-hour days to instruct Sound Transit’s personnel on the proper operation, repair, and maintenance of the system.

D. Warranty: The Contractor shall furnish one-year of Warranty service on the fan assembly that shall commence from Sound Transit’s acceptance of the tunnel ventilation system and shall continue up to and including the first anniversary of Sound Transit’s acceptance. Warranty service shall include labor and materials to replace all parts supplied under these Contract Specifications that fail in service as the result of a defect in materials, installation, or manufacture.
1.06 QUALITY ASSURANCE

A. Supplier and Installer Qualifications:

1. Ventilation Equipment and Component Manufacturers: Ventilation equipment and components specified in Article 2.01 shall be produced by either the equipment manufacturer or by firms experienced and specializing in the types of components required which comply with these Contract Specifications. Equipment and components shall be standard products of the equipment manufacturer and shall have history of satisfactory operation.

2. Installer: Equipment shall be installed by the equipment manufacturer or its authorized representative, or by a skilled and experienced Subcontractor qualified and specializing in the installation of the specified equipment. The installation Subcontractor shall be approved by the equipment manufacturer.

1.07 FACTORY TESTS AND INSPECTIONS

A. General:

1. The following specifies the factory testing requirements for the Tunnel Ventilation Equipment to be procured under this Contract. All tests described herein shall not preclude any additional standard test normally performed by the manufacturers for similar equipment.

2. The Contractor shall notify in writing of all test dates not less than 14 Days prior to the tests, including the expected duration and sequence of testing.

3. The Sound Transit’s representative may witness any or all tests unless waived by Sound Transit.

4. Observations made during the tests, and test results shall be recorded in an acceptable document form, certified by the Contractor and submitted to Sound Transit for acceptance.

5. All expenses in connection with or incidental to the testing shall be borne by the Contractor.

6. The test procedure specified for each fan shall be in the sequence required to enable subsequent testing to proceed. All ventilation equipment or component thereof, which fails to satisfactorily perform during any test as specified, shall be considered unacceptable. Failing parts shall be repaired/redesigned and the entire unit shall be retested as specified herein, at no additional cost to Sound Transit.

7. Submit reports for all factory tests and inspections according to Article 1.04, Submittals, herein.

B. Radiographic Inspections:

1. Radiographic inspection shall be performed of every hub and every blade for every fan-motor unit to be furnished under this Contract in accordance with ASNT. Acceptance criteria for radiographic testing shall be according to applicable ASTM Standards. The x-ray identification number shall be etched or engraved on each blade before assembly of the rotor. Where radiographic inspection cannot be used due to the hub thickness, the Contractor may use ultrasound testing according to ASTM A 388. The certification of visual acceptability and the x-ray procedure shall be submitted for acceptance. The x-
ray film and ultrasonic results shall be kept on file by the manufacturer for a minimum of five years.

2. If aluminum blades are steel reinforced, where steel and aluminum interface occurs, radiographic test for blades shall show the interface clearly.

C. Salt Spray Tests:
   1. For single stud mounted blades, where contact between dissimilar metal exists (stud, blade and hub), an assembly of such dissimilar metals shall be subjected to salt spray test according to ASTM B117 for an exposure period of 7 days (168 hours). The test shall not show any sign of corrosion at the end of the test.

D. Fan Rotor Over Speed Tests:
   1. Each fan rotor assembly manufactured and furnished under these Contract Specifications shall be subjected to an unwitnessed overspeed test at the factory, as specified herein, prior to assembly of the complete fans.
   2. Prior to the over speed test, each rotor assembly shall be statically and dynamically balanced by the manufacturer to the required ANSI S2.19 level for residual balance so as to provide 2.5 mil peak to peak displacement at each motor bearing during actual operation as a fan/motor assembly at design speed.
   3. After radiographic inspection and after static and dynamic balancing, each completely assembled fan impeller shall be spin tested. Spin testing of individual components, such as blades and rotors, in lieu of testing complete impellers, is not acceptable. Each fan impeller shall be spun at 125 percent of the maximum design operating speed for a period of not less than five minutes. Fan impellers shall be tested in both directions of rotation. Following each spin test, the Contractor shall perform a blade fastener torque check and shall make a visual inspection for loose blades and blade & hub surface defects. Replace defective parts and repeat the test before further testing. Certificates of visual acceptability shall be submitted for acceptance.

E. Fan Motors:
   1. Arrange for factory testing of each fan motor size. Tests shall be witnessed and unwitnessed.
   2. Fan motors shall be tested according to IEEE Publication 112 and NEMA MG-1.
   3. Witnessed Tests:
      a. One motor of each nameplate horsepower rating shall be tested at its rated speed in the presence of the Sound Transit's technical representative.
      b. Tests shall be as follows:
         1) Tests to obtain actual fan motor performance curves verifying the theoretical fan motor performance curves and other data submitted as specified herein.
         2) Tests to obtain values for the following electrical and mechanical characteristics with rated voltage and frequency applied to motor terminals:
3) Full load current in amperes.
4) No load current in amperes.
5) Full load input in kilowatts.
6) No load input in kilowatts.
7) Locked rotor current in amperes.
8) Locked rotor input in kilovolt amperes.
9) Locked rotor torque in pound-feet.
10) Calculated rotational moment of inertia of rotor in pounds-feet squared.
11) Power factor in percent at full load amperes and locked rotor amperes.
12) Motor torque in pound feet

c. A complete test of each motor shall include the following:
1) Performance speed-current and speed-torque tests.
2) Temperature test, full load.
3) Insulation resistance-temperature test shall be taken following heat run, readings being taken in degrees Fahrenheit at one-hour intervals for a period of four hours. Temperature shall be determined by the resistance method.
4) Cold and hot resistance measurement.
5) Dielectric Test: (Voltage to be applied shall be based on the voltage rating of insulation plus 1000.)
6) Motor winding resistances.
7) Motor losses, no load, half load, three quarter load and full load.
8) Vibration test.

4. Unwitnessed Tests:

a. Each of the remaining motors shall be tested at its rated synchronous speed unwitnessed.

b. Tests shall be as follows:
1) Winding resistances.
2) No load current in amperes.
3) Dielectric tests.
4) No load speed.
5) Locked rotor current in amperes.
6) Insulation resistance and winding temperature at time taking insulation resistance.
7) Vibration check.

F. Pre-Production Fan Tests:

1. The manufacturer shall perform factory tests on a pre-production model emergency fan and smoke exhaust fan.

2. The pre-production fan may be furnished as a procurement unit after pre-production testing, if all parts and components are in like new and operating condition. Each unit or component must satisfactorily pass all specified factory tests as described elsewhere herein.

3. Vibration Tests:
   a. Prior to other tests, each fan impeller shall be statically and dynamically balanced and the fan-motor unit shall successfully perform the following vibration tests. Emergency fan-motor units shall be tested for vibration in both directions of rotation.
   b. Each fan-motor unit shall be checked for obviously rough operation. Defective bearings shall be replaced, and the fan-motor unit shall be rechecked before further testing.
   c. Each fan-motor unit shall be tested for vibration. The vibration shall be measured in two radial planes 90 degrees apart (front and rear), and in the axial direction.
   d. Vibration amplitude shall be measured and recorded continuously as the fan-motor unit is accelerated from a standstill to rated design operating speed, and as the fan-motor unit coasts down from rated design operating speed to a standstill. The amplitude versus frequency chart shall be analyzed by the Contractor to determine the cause(s) of the excessive vibration. Additional testing may be required if measured vibration amplitude exceeds the specified allowance maximum, or if the specified vibration measurements reveal excessive vibration at any frequency other than rated design operating speed. Resonant frequencies shall be determined and shall be demonstrated as not to occur within fan-motor unit operating ranges. The analysis shall be submitted to Sound Transit and the cause(s) shall be corrected prior to initiation of further testing. The acceptable limits of vibration shall not exceed the limits specified herein. Measured maximum vibration shall not exceed peak-to-peak amplitudes of 0.0012 inch for fan-motor units operating at a nominal speed of 1,200 rpm or less.

4. Strain and Stress Tests:
   a. Tri-axial strain gauges shall be applied to two blades per impeller and to the hub of unloaded impeller of the pre-production fan. To accurately measure strains and stresses developed in each rotor, one strain gauge at the root, one strain gauge at the midpoint and one strain gauge at the tip of blades on each side shall be applied on a minimum of two blades. In addition, one strain gauge shall be applied on the impeller hub for
each strain-gauged blade. The strains developed during testing at rated speed shall be continuously monitored and measured. The measured strains produced under the test load shall be used to calculate corresponding stresses. Stresses results shall be submitted for acceptance. The methods of strain measurement and stress calculation shall also be submitted for approval. The Contractor shall submit the manufacturer’s certification that the measured strains and calculated corresponding stresses represent the strains and stresses developed in all other blades of the pre-production fan impeller being tested. Calculated maximum expected stresses, and the design properties of the material used to fabricate the impeller blades and hub, shall also be submitted for approval. The stresses shall not exceed requirements of Article 2.02.D.1, Materials, herein.

b. Natural frequency readings of the fan blades shall be taken and included in the test report. Procedures used to determine natural frequency shall be submitted for acceptance.

5. Performance Tests:

a. The pre-production fan-motor unit that has satisfactorily passed the manufacturer’s standard production tests and inspections, including the specified factory tests described elsewhere in this Contract Specification, shall be tested in accordance with the procedures specified in “Laboratory Methods of Testing Fans for Rating”, a joint publication of AMCA Standard 210 (ASHRAE Standard 51) using the Fig. 7 “Outlet Duct Setup” or the Fig. 16 “Inlet Duct Setup”. The setup and procedures shall be submitted for acceptance. Test data shall be recorded on AMCA data forms, or the equivalent thereof as accepted by Sound Transit. Performance test shall be conducted at the design speed of the fan with the same motor that will be used in the production units.

1) The Sound Transit’s Representative will witness the performance test.

b. For the purpose of the performance test, the fan boundaries shall be the fan inlet transition flange and the fan outlet transition flange. The fans shall be tested at the blade angle that shall produce the required design volume of air at the required pressure. This blade angle shall not be at its maximum setting. Total pressure shall be between the plane of the inlet flange and the plane of the outlet flange of the fan.

c. Performance tests shall cover the range of airflow rates from the stall line to free air delivery. Test data shall be recorded at a minimum of eight equally spaced settings of the volume regulator. Performance tests of the pre-production tunnel fan-motor units shall be conducted for both directions of airflow.

d. The performance test shall be used to verify performance of the fan. The performance test shall also verify the requirement that the total efficiency of the fan be not less than 65 percent in the exhaust or forward mode and not less than 60 percent in the supply or reverse mode.

1) In the event that the tests show that the fan-motor units do not comply with the requirements as to characteristics, performance, and efficiency, the fan-motor units will be rejected unless
changes are made therein and tests repeated until the specific requirements are met.

e. No allowance in Contract Price or Contract Time will be made for the delay experienced by the Contractor due to the redesign and repetition of the performance tests required due to the failure to meet the stipulated requirements.

f. Submit fan-motor unit performance curves derived from factory tests verifying the theoretical performance curves previously submitted. Test points shall be indicated on performance curves. The required submittal information is listed in Article 1.04, Submittals, herein.

g. Performance curves shall also be developed from witnessed or unwitnessed test data for blade angles of 5 degrees and 10 degrees above and below the design blade angle.

6. The fan shall be calibrated during testing for airflow capacity versus annulus velocity, at the duty point using laboratory grade pitot tube in the annulus and mounted through the bushings in the fan housing.

7. Record the acceleration time for each rotational direction from standstill to operating speed.

8. Sound Tests:
   a. Free field fan total sound power level test:
      1) Pre-production fan-motor unit which has satisfactorily passed all proceeding tests and inspections specified shall be tested in accordance with ANSI S12.56 to obtain sound power level data at eight-octave band center frequencies from 63 Hertz to 8,000 Hertz.
      2) The test data shall be recorded when operating at or near the design duty points in both the supply and the exhaust modes. Test data shall be submitted for approval in tabular form.
      3) At the fan manufacturer’s option noise test may be carried out concurrently with Fan Performance Test specified herein.

9. Reversal Test:
   a. The pre-production tunnel ventilation fan-motor unit which has satisfactorily passed all the above tests and inspections specified shall be subject to reversal tests. These tests shall be conducted with the AMCA 210 arrangement setup for supply mode performance testing.
      1) The test shall require three cycles of rotation reversal. Cycles of rotation reversal are defined as reversal from one direction of motor impeller rotation to the other direction of rotation, and then back to the first direction of rotation.
   b. The reversal test shall begin with the fan-motor unit operated in the supply direction of airflow for a period of 30 minutes.
   c. At the end of the first 30-minute period of operation in the supply direction of airflow, the motor shall be electrically reversed, with a 45-
second time delay imposed between the interruptions of power and re-
energizing of the motor for reversed rotation.

d. After the motor has been re-energized, the fan-motor unit shall be
operated in the exhaust direction of airflow for a period of 30 minutes.

e. The test shall be continued, with alternating 30-minute periods of
operation in the supply and exhaust directions of airflow, until six single
rotation reversals have been performed. At the end of each 30-minute
period of operation, the motor shall be electrically reversed, with a 45-
second delay imposed between the interruption of power and re-
energizing the motor for reversed location.

f. After three cycles of rotation reversal, that is, six single reversals of the
direction of motor and impeller rotation have been performed; the fan
shall be operated for a period of 30 minutes.

g. At the end of the last 30-minute period of operation, the fan shall be de-
energized, and permitted to coast to a standstill.

h. Insulation resistance of the motor windings shall be measured just prior
to the start of this reversal test, and immediately after the end of the test.
In addition, the temperature of the motor windings and of the motor
frame shall be continuously recorded throughout the test. Certification
of successful performance of the reversal test and certified test data shall
be submitted for acceptance.

10. Run-in Test

a. Each fan shall be operated continuously for a total of 12 hours in the
forward mode and 12 hours in the reverse mode, if applicable. During
reversal, fan shall be allowed to coast to a standstill, before being
restarted in the reverse direction.

11. Elevated Temperature Test

a. One preproduction unit of each type, that has passed all preceding tests,
shall undergo an elevated temperature test. The fan-motor unit shall
operate at the rated flow and pressure for a period of one hour at 482
degrees F in a closed loop system. The test will be considered a success
if the fan-motor unit is still operating at the end of the one hour period.
Any component of the fan shall not show signs of failure at the end of the
test. The fan-motor unit used for this test shall not be provided as a
procurement unit after the test is completed.

G. Fan Dampers and Tunnel Dampers:

1. Witnessed Tests:

a. The full size damper assembly shall be used for the leakage and
deflection tests.

b. A prototype shall be used for the pressure loss tests. Minimum size of
the prototype shall be 42 inches high by 42 inches wide clear inside
dimensions.
c. All testing shall be conducted in an AMCA registered Independent Testing Laboratory. The testing facility shall be approved by the Resident Engineer.

d. Leakage and pressure drop testing shall be conducted in accordance with AMCA Standard 500D.

e. Instruments shall have been calibrated not more than 180 days prior to the tests.

f. Calibration shall be traceable to the National Institute of Standards and Technology.

g. The Contractor shall conduct tests to determine the following:

1) Leakage at shut off in cubic feet per minute per square foot at 10 inches of water pressure differential across closed damper.

   a) During this test damper blades shall be subjected to the normal closing force applied to the actual damper operation.

2) Pressure drop at 2,000 FPM face velocity, based on inside of frame dimension, when damper is in full open position, in accordance with AMCA 500D.

3) Blade deflection at maximum differential pressure.

h. Elevated Temperature Test

1) One damper module and damper operator combination shall be tested to an elevated temperature of not less than 482 degrees F for one hour. The damper and the operator combination shall be operated open and closed at the beginning of the test period, and every ten minutes thereafter for one hour while the damper and damper operator combination subjected to a temperature of not less than 482 degrees F. At the end of the hour the damper and the damper operator shall be operated and closed for ten cycles. The damper and the operator combination shall operate without failure throughout the entire elevated temperature test. The elevated temperature test may be waived if the damper manufacturer and the damper operator manufacturer can demonstrate that a similar model damper and identical model damper operator combination have passed an elevated temperature test on previous projects.

2. Unwitnessed Tests:

a. Perform factory testing of each damper complete with the damper operator unit and with limit switches (both damper operator limit switches and damper blade limit switches) that will operate the damper when installed.

b. Each damper shall be operated a sufficient number of times to determine adjustments and corrections required and to assure correct operation.

c. Indicated adjustments and corrections as required shall be performed.
d. Contractor shall certify in writing that each damper ready for shipment has successfully passed the above testing.

H. Sound Attenuator Tests:

1. Independent Testing Laboratory tests shall be performed on models that are representative of the units to be supplied. On the model the following items shall be identical in size, construction, and design to those corresponding items on the full size attenuator.

2. Separation distance between baffles (minimum of two baffles required for prototype model).

3. Baffles, acoustic fill, wrapping, and perforated facings.

4. Length of the baffles in the direction of flow (height of the prototype model shall be a minimum of 36 inches).

5. Air velocity and air direction through the channel. The Independent Testing Laboratory test shall demonstrate the Dynamic Insertion Loss and Self-Noise characteristics as well as the pressure loss characteristics in accordance with ASTM E477. Detailed description of the instrumentation and measurement techniques shall be submitted. The Resident Engineer shall be notified two weeks before the performance of the test.

1.08 DELIVERY STORAGE AND HANDLING

A. All equipment shall be delivered to the work site in weatherproof containers, which clearly identify the contractor/subcontractor/installer and the equipment and accessories within the containers. Provide fan unit identification numbers on the containers.

B. Submit a schedule of all equipment deliveries pertinent to the work of this Section.

C. The Contractor shall perform all required storage maintenance in accordance with the respective equipment manufacturers’ instructions and recommendations.

D. Any blade or hub damaged by mishandling shall be replaced by Contractor.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. Emergency fans

B. Smoke exhaust fans

C. Fan motors

D. Fan motor auxiliaries

E. Interconnecting power and control Wiring

F. Fan dampers, tunnel dampers and associated controls

G. Sound attenuators

H. Local instrument panels
I. Miscellaneous appurtenances

2.02 AXIAL FAN MOTOR UNITS (EMERGENCY FANS AND SMOKE EXHAUST FANS)

A. Performance Requirements

1. Modes of Operation:

a. Each emergency fan shall be designed to operate continuously and satisfactorily in both forward/exhaust and reverse/supply modes and each smoke exhaust fan shall be capable of operating in one direction (exhaust) only. Two emergency fans will be installed in parallel at each end of the station platform in accordance with the Contract Drawings. Two smoke exhaust fans will be installed in parallel in accordance with the Contract Drawings. All fans shall be suitable for operation either individually or in parallel with the other fan. Operation of the fans individually or in parallel at or near the design duty point shall not cause overloading of the motors. When operating in parallel, the fans shall operate smoothly and with stability throughout the entire operating range at all flows and pressures without stalling. All sensors and controls shall be provided by the fan manufacturer to test, sense and assist operation of the fan and avoid stalling. Provide fans with a non-stalling blade angle from free delivery to shut-off to prevent operation in stall region.

b. In the exhaust mode, ambient air is drawn through the inlet opening from the subway tunnel and discharged through the open end of the sound attenuator towards the stack. The air temperature will vary between 24 degrees F and 482 degrees F and the air density will range from a maximum of 0.082 pound/cubic foot to that corresponding to the absolute temperature change.

c. In the supply mode outside ambient air is drawn in through the fan shaft and is discharged into the tunnel. The air temperature will vary from 24 degrees F to 104 degrees F.

d. The fans shall be capable of withstanding a temperature change from 24 degrees F to 482 degrees F in 10 minutes and continuous operation at 482 degrees F for 1 hour without suffering loss of service of the fan or any of its auxiliaries.

2. Rated Capacities and Efficiency:

a. Each emergency fan shall be fully reversible.

b. Each fan unit shall be guaranteed to produce the volumes and pressures as listed in the equipment schedule on the Contract Drawings when operating in parallel, and with an inlet air density of 0.082 lb/ft³.

c. The total efficiency of the fan shall not be less than 65 percent when operating in the exhaust or forward mode and not be less than 60 percent when operating in the supply or reverse mode.

B. Sound Requirements

1. Sound power level rating shall comply with AMCA Standard 301. Ratings shall have a certified sound power level, based on 10E-12 watts.
2. For the emergency fans the total sound power generated shall be submitted when operating in the forward/exhaust and reverse/supply mode at rated speed and design duty points. For the smoke exhaust fans the total sound power generated shall be submitted when operating in the forward/exhaust mode at rated speed and design duty point. The maximum permissible sound power levels shall be as indicated below at rated speed and design duty point.

<table>
<thead>
<tr>
<th>Center Frequency (Hz)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Power Level (referred to 10^-12 watts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Fan</td>
<td>111</td>
<td>110</td>
<td>109</td>
<td>119</td>
<td>120</td>
<td>117</td>
<td>114</td>
<td>107</td>
</tr>
<tr>
<td>Smoke Exhaust Fan</td>
<td>100</td>
<td>97</td>
<td>97</td>
<td>101</td>
<td>106</td>
<td>103</td>
<td>98</td>
<td>93</td>
</tr>
</tbody>
</table>

C. Design Requirements

1. Clearance Limitations:
   a. The Contract Drawings indicate openings in the fan rooms in which the fans will be installed and the access clearance dimensions through which the fan components can be moved for installation.
   b. The fan sub-assemblies and other components shall be provided in the maximum size and arrangement that will pass through the openings and passages without disassembly, the above sub-assembly sizes shall also permit installation and access within the limited confines of the space available.

2. Configuration Requirements:
   a. The intended installation configuration is shown in the Contract Drawings. The emergency fan unit shall be fully assembled and enclosed in a split case housing with the split along the horizontal or vertical centerline (longitudinal axis). Each fan housing shall be bolted in the field to a stable isolation base and supports.
   b. The intended installation configuration is shown in the Contract Drawings. The smoke exhaust fan unit shall be fully assembled and enclosed in a split case housing with the split along the horizontal centerline (longitudinal axis). Each fan housing shall be bolted in the field to a stable isolation base and supports.
   c. Each emergency fan shall be a horizontal or vertical shaft as shown on the Contract Drawings, single stage, and reversible axial flow type with individually adjustable blades at rest and specially designed for subway tunnel ventilation service. Each fan shall be driven by an internally mounted reversible, totally enclosed air over (TEAO) AC induction motor.
   d. Each smoke exhaust fan shall be a horizontal shaft as shown on the Contract Drawings, single stage, and uni-directional axial flow type with individually adjustable blades at rest and specially designed for subway tunnel ventilation service. Each fan shall be driven by an internally mounted, totally enclosed air over (TEAO) AC induction motor.
e. The fan housing half along the longitudinal axis shall be removable to simplify fan maintenance. The housing shall have axial bolted joints and shall have a circumferential bolted joint on both ends that will allow removal of the one half of the housing. The fan housing shall also be equipped with a maintenance access door located at the top of the blade plane that will allow removal and replacement of or adjustment of the blades without removing of the one half of the housing.

f. There shall be no exposed wiring. Sensing instrument leads shall be enclosed in conduit and prewired from the element to a separate motor junction box and from there to a common terminal box, separate from the power or motor space heater wiring, mounted on the outside of the fan housing. Openings shall be provided in the terminal boxes for the conduits as shown in the Contract Drawings.

g. Flexible connectors shall be clamped to the cylindrical fan housing ends and the matching cylindrical end of the transition duct. The clamps shall be a minimum of 3 inches wide, shall be formed to fit over the flexible connector fabric installed over the diffuser and housing, and shall be two-piece construction joined by bolts that adjust the fit and tension of the clamps.

h. Each fan motor unit shall be equipped with a monitoring system that will sense fan speed, bearing vibrations, bearing temperatures, and motor winding temperatures and provide signals to a common panel in the Electrical Room.

i. All fans shall be furnished with similar bushings located in the identical locations on each fan housing for calibration of airflow capacity cubic feet per minute (CFM) versus annulus velocity pressure (Pv), using a laboratory grade pitot tube in the annulus. Deliver fans with the bushings closed with plugs. The fan manufacturer shall supply one laboratory grade pitot tube and suitable manometer. Include a written procedure for testing the fans in the field with these instruments as a part of the Operating and Maintenance Instructions.

3. Imposed Loads:

a. Each fan and its component parts and appurtenances shall be capable of satisfactorily withstanding the affects of all stresses including stresses and loads caused by reversing the direction of the motor.

b. The fan and motor supports shall be designed to maintain proper alignment of the fan during all static and dynamic loading conditions resulting from flows in both directions.

c. The outlet transition duct and its supports shall be designed to withstand the loading imposed by all forces and at all operating conditions. Supports shall fasten to the floor only.

4. Fan Assemblies:

a. Each fan assembly shall be completely shop assembled and shall include the following:

   1) Machined hub for holding blades and suitable for mounting directly on the motor shaft.
2) Individual blades shall be secured to the hub by not less than four bolts per blade, or shall be clamped securely between the two halves of a split hub or between suitably designed and manufactured clamp plates. Blade bolts, hub bolts or clamp plate bolts shall be readily accessible.

3) Blade thrust collar.

4) As an option, single stud mounted blades shall be permitted with following conditions:
   a) Studs shall be screwed into the blade.
   b) Positive locking device shall be provided at each stud mounting to the hub.
   c) Torque required to mount the blade to the hub shall be provided. The torque shall be confirmed when connecting the blade to the hub.
   d) Provide salt spray test according to Article 1.07 Factory Tests and Inspections, herein.

5. Additional Performance Requirements:
   a. Fans shall be axial-flow type with single-speed motors, suitable for fully reversible operation where indicated. Emergency fans shall be designed to operate in the forward or reverse direction of airflow, with a capability of starting, stopping, or reversing as described in Article 2.03, Fan Motors, herein.
   b. Fans shall be capable of operating continuously at specified design points for forward and reverse flows where indicated.
   c. Brake horsepower shall not exceed the nameplate horsepower of the fan-motor while operating in the stable range in either flow direction.
   d. Operation of emergency fans and smoke exhaust fans shall be stable throughout a range of pressures one inch w.g. above and below the steady-state design operating point.

D. Materials

1. Impeller hub and blades shall be fabricated of aluminum alloy castings, or forgings (ASTM B 247), or steel (ASTM A588, Grade A) suitable for the specified performance and environment. Fan rotating components shall be designed such that no measured or calculated stress level shall exceed 50 percent of the components materials yield strength at specified performance and environment. Fan blades in each impeller shall not vary in weight by more than 2 percent. Each blade shall be stamped with its accurate weight in pounds to within two decimal points. Blades shall be manufactured from a homogeneous material as specified herein and shall have no cast-in or embedded material of any kind. The pitch of the blades shall be manually adjustable without removing impeller from fan unit.
2. The ratio of the hub diameter to the fan housing diameter shall not be less than 0.35. The hub shall have index marks embossed or engraved to show the design operating blade setting and additional settings for a minimum of five additional increments of stagger angle with not less than two on each side of design blade setting.

3. Fan housings, including motor mounts and motor supports, shall be fabricated of hot-rolled steel. Fan housing shall not be less than 1/4 inch thick steel. Fan housing shall be provided with split joints, bolted with gaskets, suitable for all operating conditions as specified, to facilitate disassembly and removal of motor and rotor without removal of entire fan-motor unit or any part of adjacent ductwork. Welds located in the air stream shall be ground smooth.

4. Flanged rings shall be continuously welded to the outer periphery at each end of the fan housings, or flanges may be rolled as part of the fan housing. Flange thickness shall be not less than fan housing thickness. Flanges shall not be less than 3 inches wide. Flanges shall have punched or drilled holes equally spaced not more than 8 inches on centers to permit adjacent elements to be bolted to the housings.

5. Access doors, with gaskets, in the fan housing shall be provided for easy access to the fan blades and blade locking devices. Access doors shall be of the quick-release type, with suitable latches and hinges. Access doors shall have minimum dimensions of 12 inches wide by 12 inches high. Access doors sizes and locations shall be selected by the manufacturer. The gasket used to provide airtight access doors shall be suitable for all operating conditions as specified.

6. The rotor assembly shall be fastened to the motor shaft by means of an accepted keyed positive locking device. The rotor assembly shaft shall be an extension of the drive motor shaft.

7. Motor mounts and motor supports shall be designed to support the entire weight of the impeller and the motor, and to maintain the alignment of the fan-motor unit assembly in the specified mounting position and to maintain vibration levels within the specified limits. Motor supports shall be sufficient in number to provide the required strength and rigidity and shall be continuously welded to the motor mount and to the housing. Fan motor and fan rotor assembly shall be totally enclosed within the fan housing and not protrude at either end of the fan housing.

8. Nosepiece cover plates, access doors, and aerodynamic separation plates, and straightening vanes where provided shall be secured by means of positive fastening devices which are fully effective for the required directions of impeller rotation, for all blade settings, and for all conditions of operation specified herein.

9. Fan motor unit assembly supports or braces shall be of carbon steel not less than 3/8 inch thick. Supports for the fans shall include fan motor unit structural steel base with vertical supports extending from the base to the fan housing centerline flange and with horizontal thrust plates extending over the full length of the fan housing.

10. Gaskets shall be provided between adjacent companion flanges of fans, cones, and flexible connection. Width of gasket shall be same as flange width. Gaskets shall be capable of withstanding an ambient temperature of 482 degrees F for a period of one hour without degradation of sealing ability and without emitting toxic or noxious fumes.
11. Sufficient lifting eyes shall be provided on each fan assembly to facilitate on-site installation and removal of the fans. Upper removable section of fan housing shall be provided with at least two lifting eyes suitably located.

12. Bolts shall be not less than 1/2 inch minimum in diameter. All bolts unless otherwise noted shall be Type 316 stainless steel conforming to ASTM A 193, Grade B8M on B8MA. Nuts compatible for use with the above bolts shall be alloy steel conforming to ASTM A 194, Grade 2H. Washers and lock washers used on the fans and components shall be of Type 316 stainless steel.

E. Fan Inlet and Outlet Transition Ducts

1. Fan transition ducts shall be provided as indicated in the Contract Drawings. Transition ducts shall be according to Article 2.06, Sheet Metal Ductwork, herein.

2. Transition Ducts shall be fabricated of hot or cold rolled steel conforming to the requirements of ASTM A36 and shall have companion flanges rolled integrally or continuously welded at both ends.

3. Ductwork transitions for emergency and smoke exhaust fans shall be fabricated in sections as required to facilitate installation or removal from the fan room. Each section shall be fabricated and assembled flanged with a gasket, and bolted together to form an airtight perimeter. Flanges and reinforcing angles shall be continuously welded to each duct or section. Terminating ends of reinforcing angles shall be rounded or beveled.

4. Steel for ductwork reinforcement and section connection flanges shall be structural angles conforming to the requirements of ASTM A36. Angles shall not be less than 3 inches by 3 inches by 1/4 inch thick.

5. Flanges shall have punches or drilled holes equally spaced not more than 8 inches on centers to permit bolting to adjacent components. Holes in flanges shall match the holes in fan flanges, or mating duct work, damper or sound attenuator.

6. Access doors shall be of steel construction and shall be provided in the ductwork where indicated in the Contract Specifications. Each access door shall have a clear opening size not less than 30 inches by 36 inches, unless otherwise indicated in the plans. Access doors shall be provided with not less than 1/4 inch thick silicone gaskets to ensure airtight construction. Access doors shall be provided with bolt type latches, welded full height continuous hinge, handhold bar on top of access door and designed so that one person can open the door.

7. Painting of all carbon steel items inside and out shall be in accordance with Article 2.08, Painting, herein.

F. Nameplates

1. Each fan shall be provided with a stainless steel nameplate permanently stamped with the name of the manufacturer, manufacturer's identification number, fan type, fan designation number, shop order numbers, serial number of fan, year of manufacturer, maximum safe operating speed of fan in revolutions per minute, fan impeller diameter, first critical speed in revolutions per minute, maximum design operation speed and corresponding volume of air delivered, and total and velocity pressures and density specified. The nameplate shall be securely screwed or riveted to the exterior of fan housing in a conspicuous position.
2. Each fan shall be provided with a stainless steel enamel plate that shall bear, in numerals not less than 3 inches high, the Contract’s fan designation number as indicated on the Contract Drawings. The plate shall be securely screwed or riveted to the exterior of the fan housing adjacent to the fan nameplate.

G. Painting:

1. All carbon steel components including, but not limited to, the entire fan housing inside and out, the duct work including the transition duct and the inlet cone inside and out, on the straightening vanes, nosepieces and the motor supports shall be painted in the shop in accordance with Article 2.08, Painting, herein.

H. Flow Switches

1. The emergency fan system shall be furnished with two flow switches to sense the fan’s mode of operation (forward/exhaust and reverse/supply) as indicated on the Contract Drawings. The smoke exhaust fan system shall be furnished with a flow switch to sense the fan’s mode of operation in forward/exhaust as indicated on the Contract Drawings. Normally open contacts shall be wired to the control junction box.

2. The flow switches shall be differential pressure type capable of detecting a difference in air pressure between the intake and discharge sides of the fan to provide positive indication of airflow generated by the fan. Provide airflow indication for local and remote indications of fan operation and forward and reverse airflow.

3. Differential pressure switches shall be diaphragm operated to actuate a single pole double throw snap action switch. Motion of the diaphragm shall be restrained by a calibrated spring that can be adjusted to set the exact pressure differential at which the electrical switch will be actuated. Motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage. Set point adjustment shall be screw type with set point indicated on a visual scale.

4. Housing to contain both pressure switches shall be weatherproof, 16 gauge steel zinc plated with gasketed cover. Housing shall be of sufficient size to house both switches, complete with bulk head fittings to accept the 1/8 inch stainless steel tubing from the probes. Housing shall be mounted in an accessible location on the fan or one of the sound attenuators.

5. Electrical rating for the switches shall be 15 amps, 120 volts, 60 Hertz. Switches shall be suitable for operating in temperature range of minus 0ºF to 160ºF.

6. Operating range shall be 0.2 inch w.g. to 1 inch w.g. or as otherwise recommended by the fan manufacturer.

2.03 FAN MOTORS

A. General:

1. The performance of the fan motors furnished shall conform to the accepted actual fan motor factory test performance curves and other accepted data.
2. Motors furnished shall be designed for satisfactory operation in tunnel atmospheres exposed to excessive moisture, industrial fumes and non-metallic dust. The motors shall withstand long periods of idleness in such conditions without damage or deterioration.

3. Description of Fan Motors: Fan motors provided shall be the motor manufacturer's "energy efficient" type, as defined by NEMA MG-12.58, horizontal face mounted, squirrel cage induction motors, NEMA Design as applicable, designed for continuous operation on alternating current.

4. Qualifications of Motor Manufacturer: Fan motors shall be the product of an established motor manufacturer who has been regularly engaged in the production of motors of the required capacities and whose products have operated successfully for a period of at least five years.

5. Motor Manufacturer: Fan motors shall be manufactured by the manufacturer whose name appears on the theoretical fan motor performance curves and on the other submitted data.

6. Motor Design Criteria:
   
a. General: Provide fan motors, which will be powered from Motor Control Centers, conforming to the following:

   1) Motors shall be rated in accordance with NEMA Standards for locked rotor input (kilovolt amperes per horsepower) required meeting the specified performance.

   2) Motor enclosures for the axial fans shall be totally enclosed air over type.

   3) Insulation for the fan motors shall be Class H minimum with a Class F temperature rise when tested at service factor of 1.15 without the air over cooling effect.

   4) Voltage rating shall be 460 volts.

   5) Frequency rating shall be 60 Hertz.

   6) Motor shall be designed for operation with a 3-phase power supply.

   7) Synchronous speed for the emergency and smoke exhaust fan motors shall not exceed 1200 rpm.

   8) Motor efficiency and losses shall be determined and motors labeled in accordance with NEMA MG1 12.58 (IEEE 112, Test Method B or E). The guaranteed efficiency shall not be less than the minimum efficiencies listed in NEMA MG-12.58.2, Table 12-8.

   9) Motors shall be designed for continuous operation at full load with air temperature of 482 degrees F for 1 hour. This is a fire emergency operating condition.

b. Starting:
1) The axial fans will use soft starters as specified in Division 26, Electrical, Section 26 24 14, Motor Starters for Tunnel Fire Ventilation Fans. The motors shall be designed to accelerate the fans from standstill to the operating speed, while under maximum fan load, at least four times in 1 hour, without thermal damage to the motor, with rated voltage applied to the motor.

2) The motors shall be capable, under the specified operating conditions of accelerating the impeller from standstill to rated rotational speed, in either direction, in not more than 30 seconds after being energized at rated voltage.

3) In addition, the axial fan motors shall be designed for three equally spaced reversals of the fan within one hour of continuous operation. The reversals shall incorporate a 45-second delay between interruption of power and re-energizing of the motor for reversed rotation.

c. Temperature Rise: Axial Fan Motors

1) Temperature Rise: When run continuously for an indefinite period at rated voltage, at design speed, and at the maximum fan load the temperature rise of the insulated windings (above an ambient temperature of 104 degrees F) shall not exceed the values established by NEMA Standard MG1-12.42 for a Class F insulation system of the motors when measured by resistance method, even though the actual insulation system is Class H. The maximum fan load in each case is the maximum horsepower that the fan can absorb under all air flow and/or pressure variations in the stable operating range at the corresponding speed, and not the horsepower absorbed at the operating point corresponding to the pressure specified. With the same continuous operation and loading as above, except with a voltage variation of 10 percent above or 10 percent below the rated voltage, the temperature rise shall not exceed the values established by NEMA MG1-12.42 for a Class F insulation system of the motors when measured by resistance method even though the actual insulation system is Class H.

2) When started four times in 1 hour, as described in Article 2.03.A.6.b, Starting, herein, the motor temperature rise (above an ambient temperature of 104 degrees F) shall not exceed the values established by NEMA Standard MG1-12.42 for the Class F insulation system of the motors when measured by resistance method. The first start shall be with the motor at ambient temperature and any two successive starts may be within a 10-minute period.

3) When subjected to the reversal tests described in Article 2.03.A.6.b, Starting, herein, the motor temperature rise (above an ambient temperature of 104 degrees F) shall not exceed the values established by NEMA Standard MG1-12.42 for a Class F insulation system, even though the actual insulation system is Class H.

d. Locked Rotor Current and Torque:
1) The locked rotor current at rated voltage and frequency shall not exceed the values listed in NEMA MG1.

2) The locked rotor torque shall not be less than 125 percent of the full load torque at rated voltage and frequency.

3) The combined inertia of the fan wheel assembly and the motor shaft shall not exceed the values listed in NEMA MG-1.

e. Noise and Vibration:

1) Motors shall be designed to operate free from excessive hum, whine or vibration at all speeds within the operating range from standstill to 100 percent of rated speed.

2) The maximum motor sound pressure level in decibels (based on 0.0002 micro bar) shall be measured at all speeds between standstill and 100 percent of rated speed at a distance of 3 feet from the motor in a hemispherical free field under no load conditions.

3) The manufacturer shall balance each motor to provide a peak vibration velocity less than 0.15 inch per second at each motor bearing when tested for vibration in accordance with NEMA MG-1 Part 12.

B. Materials:

1. Insulation: The insulation shall be a sealed insulation system suitable for the operating conditions specified above.

2. Cores: Primary and secondary cores shall be built up of fully insulated, separately punched steel plates laminated and rigidly supported in the stator frame or on the rotor.

3. Rotors: Bars and shorting rings in rotors shall be fabricated of low resistance metal. End connections shall be cast or welded or brazed together.

4. Frames: Motor frames shall be fabricated of cast iron or heavy fabricated steel.

5. End Brackets (End Shields): End brackets shall be fabricated of cast iron or heavy fabricated steel.

6. Space Heaters: Space heaters (strip or cartridge type) shall be provided in each motor frame and shall be rated for 120-volt, ac, single-phase operation.

7. Motor Leads: Motor leads shall be insulated stranded copper conductors secured to prevent jarring loose or coming in contact with moving parts. Motor leads shall be UL listed and conform to ICEA requirements based on voltage, current, enclosure rating and maximum enclosure temperature during operation. The motor leads shall be protected with a high temperature fiberglass sleeve from the motor housing to the power junction box on the motor.

8. Motor Conduit and Junction Boxes: Conduit and junction boxes and covers shall be fabricated of cast iron or steel and be located on the outside of the fan housing. Matching surfaces shall be machined and boxes shall be provided with stainless steel screws.
9. Motor Shafts: Motor shafts shall be made of high grade cold rolled steel, with shaft extension carefully machined to NEMA dimensions. Motor shafts shall be of ample size as to ensure rigidity and the satisfactory operation with the additional loads imposed by the impellers.

C. Construction

1. Windings:
   a. The stator windings shall be securely retained in core slots with end connections braced, to withstand the highest torque produced.
   b. Two 100Ω, three wire platinum resistance type temperature RTD sensing detectors shall be provided in each stator (phase) winding. The RTDs shall be corona resistant. The detector leads shall be wired internally to a junction box (separate from power or motor heater wiring) mounted on the motor. This "signal" junction box shall contain a terminal block large enough for all of the motor winding RTDs plus the wiring for the flow switches, motor bearing temperature RTDs and vibration sensors. A similar terminal box shall be provided on the outside of the fan housing with factory installed conduit and wire routed to the signal junction box on the motor. The accuracy of RTDs shall be +/- 1 degree F at 32 degrees F.
   c. The RTDs shall be connected to a control terminal box on the fan housing for processing. Coordination with the controls contractor will be necessary to ensure that temperature and vibration levels are monitored and alarmed as determined by the motor manufacturer.

2. Insulation:
   a. The sealed insulation system shall be the type wherein the entire stator is impregnated with an epoxy resin.
   b. The epoxy resin impregnation shall be performed after fully insulated stator coils have been wound in core slots of the stator and after end turns have been braced and connections have been made and insulated.
   c. The impregnation by the vacuum pressure process shall consist of multiple submersions of the complete stator in liquid epoxy resin followed by baking for curing.
   d. The impregnation shall be performed in such manner that the epoxy fully penetrates the core slots and coils, including end turns, forming a solid winding encapsulation without air voids.

3. Cores: Slots in individual plates and laminated cores shall be smooth and without burrs that may damage coil insulation.

4. Rotors:
   a. Rotors shall be electrically, statically, and dynamically balanced.
   b. Rotors shall be centrally located in the stator bore and shall be easily removable from motors.
c. Rotors of motors shall operate safely and without excessive vibration at all speeds up to 125 percent of their maximum operating speed. (For motor vibration requirements, see Article 2.03A.6.e, Noise and Vibration, herein.)

d. Conductivity shall not depend on riveted or bolted connections or on soft solder.

5. Frames:
   a. Frames shall be accurately machined and drilled for end brackets and shall be arranged to rigidly support the primary core laminations.
   b. Faces shall be provided for frames and shall be cast integral with or rigidly secured to the frame.
   c. Self-relieving, anti-corrosive drain plugs shall be provided at bottom of motor frames.
   d. Bolt holes in face shall be jig drilled.
   e. Motor frames shall be provided with removable lifting lugs.

6. End Brackets (End Shields):
   a. The brackets shall be secured such that alignment is not dependent on bolt or dowels.
   b. The brackets shall be provided with the strength and rigidity to withstand the electrical and mechanical stresses induced by full voltage starting and reversing.
   c. The opposite drive end bracket shall be supplied with a coated insulated bearing bore to eliminate damage caused by circulating shaft currents.

7. Space Heaters:
   a. Space heaters shall be of such number and wattage to prevent condensation on all internal motor parts in climatic conditions encountered in the fan chambers. The ambient temperature in the fan chamber could be as low as 24 degrees F.
   b. The heaters shall be energized whenever the motor is not in operation and shall be automatically de-energized whenever the motor is in operation. The heaters shall be energized while motors are in onsite storage.
   c. The space heaters shall operate at 120 volts.
   d. Space heaters shall be provided with leads, terminated in a separate junction box on the motor that are not common to either the power or the signal wires. Furnish a separate terminal box on the outside of the fan housing with conduit between the motor junction box and the fan housing terminal box and factory wire between them.

8. Motor Conduit and Terminal Boxes:
a. Each axial fan motor shall be provided with separate junction boxes for the power supply wires, the space heaters, and the signal wires (motor winding RTD, vibration monitoring system and fan/motor bearing RTD) on the outside of the fan housing. The boxes shall be stainless steel NEMA 4X.

b. Boxes shall be of sufficient size to permit the making of all required connections and the entrance of flexible conduits.

c. The location of conduit and junction boxes on motors and the fan housing shall be as shown on the approved working drawings.

9. Motor Shafts:

a. Shafts shall be constructed of corrosion-resistant high grade cold rolled steel material, and constructed to support and drive fan impeller.

10. Motor Bearings:

a. Motors shall be equipped with anti-friction bearings. Bearing design shall be based on ABMA 9 or 11, and shall have a minimum L-10 life of 50,000 hours at maximum capacity and maximum speed based on the bearing load imposed by the driven equipment.

b. Motor bearings shall be constructed of alloy steels and shall be of the ball or roller type and shall be grease lubricated and suitable for continuous operation over the specified speed range.

c. The bearings for the motors shall be made by one manufacturer and shall be of standard sizes carried in stock by the manufacturer.

d. The bearing housings shall be of a type to permit disassembly of the motor without exposing or disturbing the bearing elements.

e. Inner races shall be held on the shaft by a press fit, or shrink fit, such that the shafts are not damaged when bearings are replaced.

f. The inner race, rolling elements and the outer race of each bearing shall constitute a factory-assembled unit so constructed that the parts cannot be disassembled or interchanged in the field with similar parts of other bearings.

g. The bearing at one end of the rotor shaft shall provide through its rolling elements for the maximum axial thrust to which it may be subjected.

h. The bearing at the other end of the shaft shall provide for axial expansion of the shaft by means of a floating outer race.

i. The bearings shall be supported in cast iron or cast steel housings.

j. Each bearing housing shall constitute an individual assembly to be bolted to the end bracket in such a way that the motor can be dismantled and the stator removed without having to remove the bearing from the shaft.

k. Lubrication lines for the motor bearings shall be Type 316 stainless steel and be routed to an accessible area on the outside of the fan housing for ease of maintenance.
l. The bearing housings shall be designed and constructed for grease lubrication in such a way that the lubricant will not escape along the shaft to the inside or the outside of the motor.

m. To prevent over-lubrication, an overflow or relief pipe shall be provided which is easily accessible and visible when filling the bearing. The overflow shall be open at all times and so constructed that dirt is excluded without the use of screw caps or other devices to be manipulated by operators.

n. The contractor shall submit for approval the characteristics of the lubricant the motor bearing manufacturer recommends for the bearings for the type of service, given ambient temperatures and the maximum fire emergency temperature condition. The lubricant recommended shall be furnished and applied immediately after construction of the motors in amounts sufficient to provide complete initial lubrication.

o. Each fan/motor bearing shall be furnished with a vibration monitoring system, designed and installed for integration with the remote I/O network. The vibration monitoring system shall be a two-wire, current-loop powered system operating on 4-20 mA base. The velocity sensor shall use solid-state, epoxy-encapsulated circuitry with a piezoelectric crystal and output current proportional to velocity. The system shall have a frequency response range from 10 Hz to 10,000 Hz. The vibration monitoring components shall be designed, constructed, and capable of full operation for 482 degrees F for 1 hour, 100 percent humidity, and blowing rain. Encasements and enclosures shall be NEMA 4X stainless steel including lubrication lines. The accuracy of the vibration sensor shall be a maximum of 5 percent of detector level within temperature range.

1) The manufacturer shall determine "baseline", "alert", and "alarm" vibration level values and include these values in the Operational and Maintenance Data. The alert level shall relate to general wear and/or minor defects indicating that maintenance is required. The alarm level shall relate to dangerous vibration caused by damage and/or sudden out-of-balance conditions.

2) The controls shall be programmed to "alert" and "alarm" vibration levels as determined by the fan/motor/bearing manufacturer.

p. Each fan/motor bearing shall be furnished with a three wire, 100Ω platinum resistance thermal detector (RTD). The RTDs shall be corona resistant. The accuracy of RTDs shall be +/- 1 degree F at 32 degrees F.

1) The manufacturer shall determine "baseline", "alert" and "alarm" bearing temperature values and include these values in the Operation and Maintenance Data. The alert level shall related to general wear and/or minor defects indicating that maintenance is required. The alarm level shall relate to dangerous temperatures caused by damage and/or failure.

2) The controls shall be programmed to "alert" and "alarm" bearing temperature levels as determined by the fan/motor/bearing manufacturer.
11. Motor Nameplates: Each motor shall be provided with two stainless steel nameplates and connection diagrams. Nameplate shall be stamped with the name of the motor manufacturer, the motor horsepower, frame size, voltage, phase, frequency, insulation type, temperature rise, ambient temperature, full load current, locked rotor amperes in addition to indicating code letter, speed in revolutions per minute, motor type, service factor, motor serial number, bearing numbers and shop order number. One nameplate and connection diagram shall be furnished on the motor and the other riveted or screwed to the exterior of the fan housing immediately adjacent to the fan nameplate.

12. Painting: All exterior surfaces of motors shall be painted except for nameplates and machined surfaces to receive appurtenances, in accordance with the requirements specified in Article 2.08, Painting, herein.

2.04 FAN DAMPERS AND TUNNEL DAMPERS

A. General:

1. Dampers shall be the product of a single manufacturer, and like components shall be furnished by a single supplier.

2. Dampers shall be designed for either horizontal or vertical installation as required.

3. Damper sizes shall be understood to signify the dimensions inside the damper frame.

4. Dampers shall have a net free area of not less than 80 percent measured to the inside of the damper frame when damper blades are fully open.

5. Dampers shall be arranged for two blade positions: fully opened and fully closed.

6. Dampers shall be furnished complete with components and incidentals as specified herein; with structural-support elements and hardware required for installation of the dampers and with additional accessories which may be needed in order to meet the performance requirements as provided in these Contract Specifications.

7. Upon loss of electric power dampers shall move to the power-off position (open or closed) as indicated in Contract Drawings.

8. The dampers shall be designed to be readily assembled in the field from modules. Each damper module shall be of the multiple-parallel-blade type, with an independent channel frame; and shall be factory-assembled complete with frames, blades, shafts, bearings, seals, linkage, and intermediate supports, both horizontal and vertical framing members, required at the head, sill, mullion, and jambs of each damper assembly to erect the modular panels into composite dampers which are functional as specified herein.

9. Multiple damper modules may be operated by use of jack shafting.

10. Each damper module shall have integral channel frames with connecting linkage between modules and operators which shall permit the blades in each damper assembly to operate in unison. Modules shall be individually removable from composite assembly.
11. Dampers shall be fabricated in multiple sections where required. Each multiple section shall be match marked with stencils in a conspicuous location for identification at the site. The sections shall be interconnected with bolted splice plates. The sections shall be of such size which can be brought into the installation locations through the access provided and to facilitate handling, erection, and disassembly.

12. Each damper section consisting of one or more modules shall be provided with two external blade-mounted position limit switches for remote indication of two damper positions, fully open and fully closed. Two sets of contacts shall be wired in series. One set to indicate damper is fully closed and one set to indicate damper is fully open. A third set of contacts shall be wired in parallel to indicate damper is not fully open for the fail open type dampers and to indicate damper is not fully closed for the fail close type dampers. Terminate damper monitoring circuits in one terminal box.

13. Mullion supports shall be designed by the damper manufacturer. The mullions shall be full length and width and height of the dampers. Mullion supports shall be of galvanized steel, and shall have punched or drilled holes, equally spaced for damper module attachments. Number of holes and space between the holes shall be selected by the damper manufacturer. Mullion supports shall be installed by the Installing Contractor. The Contractor shall recommend the mullion attachment method for mullion attachment to damper companion flanges and mounting frames and align the equipment with the embedments. The mullions shall be designed according Article 2.04.D, Design Criteria, herein. Mullion deflection shall not exceed total deflection of damper blade and shaft assembly as specified in Article 2.04.D, Design Criteria, herein.

14. Temporary supports and bracing shall be provided to maintain dampers square and rigid at all times during handling and erection.

15. Dampers provided shall be parallel acting, multiple blades, and electric motor operated type, with associated open and close limit switches. The location of damper operators shall be as shown on the Contract Drawings.

16. Damper blade shafts shall be provided with crank arms connected to a linkage bar such that damper blades may be rotated 90 degrees to open or closed position by movement of damper operator arm. Damper blade shaft axis shall be in the horizontal plane. The damper operator shall hold damper blades firmly against stationary stops in the closed position.

B. Manufacturer’s Qualifications: Dampers and damper operators shall be the products of a manufacturer who has not less than five years experience in transit industry in manufacturing dampers and damper operators as specified herein.

C. Damper and Damper Operator Manufacturer: The damper and damper operators shall be manufactured by the manufacturer(s) whose names appear on the submitted data.

D. Design Criteria: Dampers shall be designed to produce industrial, heavy-duty rigid units that will withstand encountered operation, erection and transportation stresses.

1. Temperature Operating Range: Dampers and damper operators for the emergency and smoke exhaust fans shall be capable of satisfactorily operating through the normal ambient temperature range of 24 degrees F to 104 degrees F and under fire conditions for air stream temperatures of 482 degrees F for 1 hour.
2. Damper Blade and Shaft Assembly Deflection: Damper blade and shaft assembly deflection shall not exceed 1/180 of the span length between centers of shaft bearings with damper in closed position while withstanding a maximum combined conditions of pressure differential of 16 inches of water gauge and 482 degrees F or fan shut off pressure whichever is greater.

3. Air Leakage: Back pressure air leakage through the damper assembly shall not exceed 25 cubic feet per minute per square foot of damper face area while in the fully closed position and while withstanding a maximum pressure differential of 8 inches of water gauge.

4. Pressure Loss: Pressure loss through the damper assembly shall not exceed 0.15 inch of water in the fully open position with a maximum face velocity of 2,000 feet per minute.

5. The entire damper installation shall be designed to withstand, with the blades closed, repetitive loading of 83 lbs/sq foot (16 inches water gauge) due to pressure transients applied to either side of the damper.

6. Dampers and their associated structural supporting members shall be capable of withstanding a maximum differential static pressure across the damper of 16 inches water gauge, and a minimum differential static pressure of 6 inches of water gauge for 2,000,000 reversals. Installed dampers shall withstand maximum static pressure caused by fan operation against a closed damper.

7. Linkage Bars:
   a. Linkage bars shall be designed to withstand without exceeding allowable limits of deflection twice the maximum operating force of the damper operator.
   b. The vertical movement of linkage bars shall be accomplished by the rotation of crank arms on damper operators. A turnbuckle linkage adjustment shall be provided with each linkage to provide a convenient means of adjusting the length of the connecting rod.

E. Material:

1. Damper Frames:
   a. Damper frames for support of damper blade shafts shall be fabricated from ASTM A36 structural steel channel sections.
   b. Channel sections shall be not less than 6 inches web. The damper frame shall have three inch flange on the mounting side and two inch on the opposite side.
   c. Damper frames shall be provided with corner bracing and lifting lugs and all joints shall be continuously welded. All welds in the air stream, except fillet welds, shall be ground smooth (ANSI 125 in accordance with ANSI B46.1, Part I).
   d. Stationary blade stops shall be provided on damper frames, welded in place, against which damper blades shall rest when blades are in full open or closed position. Stops shall serve to close the space between ends of blades and the damper frame without interfering with rotation of damper blades.
2. **Damper Blades:**
   a. Damper blades shall be fabricated from stainless steel sheet conforming to the requirements of ASTM A 666, Type 304, Grade A, No. 2B Finish on exposed surfaces.
   b. Sheet thickness shall be not less than No.16 United States Standard Gauge (USSG).
   c. Damper blades shall be provided with side seals.
   d. Blades shall be airfoil shape and shall be capped at the ends with welded seams and joints.
   e. Damper blades shall not be longer than 46 inches.
   f. The width of damper blades measured in the direction of airflow shall not be less than six inches and shall not be greater than 12 inches. Damper blades in the open position shall not extend beyond the damper frame.
   g. Damper blades shall have metal-to-metal overlap in the closed position.
   h. Blades shall be sealed at all edges by stitch welding and welds shall be ground smooth (ANSI 125 in accordance with ANSI B46.1, Part I).
   i. Fasteners for attaching blades to shafts shall be stainless steel bolts, nuts and lock washers. Fastener size to be determined by manufacturer.

3. **Seals:** Blade jam and edge seals shall be flexible stainless steel.

4. **Blade Shafts:**
   a. Blade shafts shall be full length and shall be provided to support damper blades fabricated from stainless steel rounds conforming to the requirements of ASTM A276, Type 304 or 303, Condition A, Class C conditioning.
   b. Blade shafts shall be not less than 3/4 inch in diameter or square.
   c. Shafts shall be provided with holes for blade fasteners and with machined ends to fit shaft bearings.

5. **Shaft Bearings:**
   a. Shaft bearings shall be provided to support blade shafts.
   b. Bearing housings shall be cast iron or cast steel. Pressed steel housings are not acceptable.
   c. Bearings shall be flanged type, self-aligning sleeve bearings with self-lubricating carbon graphite cartridges.
   d. Bearing flanges shall be fastened to the outboard side of the damper frames, by four hexagonal head bolts and lock washers.

6. **Linkage Bars:** Linkage bars shall be Type 304 stainless steel not less than 1/4 inch thick by 3/4 inch wide, end mounted type designed to provide adjustment between blades.
a. Guided linkage shall be provided to prevent side loading at linkage connections.

b. Linkage pivots shall be oil impregnated bronze bearings with Type 303 or 304 stainless steel pins.

c. Turnbuckles shall be stainless steel.

7. Lifting Lugs: Lifting lugs shall be of steel and a minimum of four lugs (2 on each side) shall be provided on each damper frame.

F. Construction:

1. Damper Fabrication:

a. Dampers and damper companion flanges and damper operator base support shall be fabricated in accordance with accepted working drawings, as specified and as shown on the Contract Drawings.

b. The work shall be fabricated from new material, free from mill scale, flake rust and mill pitting.

c. The work shall be formed and finished without distortion to shape and size with sharp angles and lines.

d. All joints in damper frames shall be continuously welded.

e. Metal work bent by shearing or punching cannot be used.

f. Holes shall be punched or drilled for fasteners. Hole spacing for the damper frame flange channels shall be spaced not more than 8 inches center to center and holes shall be equally spaced.

g. Re-entrant corners shall be shaped notch free.

h. Edges of work shall be ground smooth.

i. Brackets, lugs, and similar accessories shall be included as part of the metal work.

j. Damper operators shall be mounted on damper frames on a base support welded to the damper frame. The base support shall be in a horizontal plane after field installation. The support shall be reinforced to prevent deflection of the operator from its normal path when the operator is operating under load.

k. Nameplate:

1) Each damper shall be provided with a stainless steel nameplate stamped with the name of the manufacturer, damper designation number, damper serial number, bearing numbers, and shop order number. The nameplate shall be located in a location conspicuous after installation.

2) Each damper shall be provided with a stainless steel enamel plate that shall bear, in numerals not less than 3 inches high, the Contract’s damper designation number as indicated on the
2. Damper Operators  

a. General  

1) The Contractor shall furnish and install the damper operators on damper as shown on the Contract Drawings and as specified herein. Damper manufacturer shall select number of damper operators required for particular damper size, minimum of two damper operators required per damper. All operators shall be electric rotary type quarter turn actuators and shall be identical, except as otherwise specified herein.

2) The operator shall be capable of changing the position of the damper blades from fully closed to fully open, or from fully open to fully closed in not more than 20 seconds. The application of full stall torque shall not damage the motor. The operator shall be capable of maintaining the damper in closed position and opening damper against a pressure differential of 16 inches of water gauge or fan shut-off pressure, whichever is greater.

3) The motor-operators shall be furnished with spring-actuated devices capable of driving the dampers to their "fail-safe" positions within a period of 15 seconds after the operators are de-energized. The "fail-safe" position of a damper (normally open or normally closed) is defined as the position which the damper assumes when its operators are de-energized. The spring-return devices shall be fully operational as specified throughout exposure to ambient and airstream temperatures of 482 degrees°F for a period of not less than one hour. The fail-safe position of dampers is shown in Contract Drawings.

4) Particular attention is called to the fact that the operators are to be installed in unheated Fan Rooms or locations where each unit and its internal components may be subjected to the ambient temperature range, including both upper and lower limits, specified herein before. The adjustable switches furnished with each unit shall serve to control the crank arm movement as well as to transmit and receive signals over the ventilation control system; therefore, all switches and their contacts shall be rugged and reliable furnishing complete opening and closure, under the full temperature range specified.

5) The damper operator shall be sized for the opening, closing and running torque duty of the damper. The unit shall operate on 120 volts, single phase, 60-hertz power. Damper operator horsepower shall not exceed 1/3 horsepower.

6) The damper operator shall include the motor, actuator unit gearing, position limit switches, torque switches, de-clutch lever, and hand-wheel as a self contained unit.

7) Each damper operator shall be provided with a position indicator, of sufficient size to be visible from the floor, to indicate the damper position.
8) Motor leads and position limit-switches (internal to damper operator) contacts shall be factory-wired to cast iron weatherproof terminal boxes. Terminal box shall be mounted to the motor mounting plates. External limit switches shall be wired to separate weatherproof terminal box. Both terminal boxes shall have tightly-fitting, gasketed covers designed to resist the entrance of dust and fluids, and shall have threaded conduit openings.

b. Motor

1) The motor shall be specifically designed for damper operator service and shall be of high starting torque, totally enclosed, non-ventilated construction. Motor insulation shall be a minimum NEMA Class F, with a maximum continuous temperature rating of 311 degrees F (rise plus ambient) for the duty cycle specified.

2) The motor shall be of sufficient size to open or close the damper at the maximum encountered torque. The motor shall be capable of operating at plus or minus 10 percent of the specified voltage. The motor duty rating shall be sufficient for at least five continuous cycles (open-close-open, or reverse) without exceeding its temperature rating. Motor bearings shall be of the anti-friction type, and permanently lubricated.

3) The motor shall be an independent sub-assembly such that the power gearing shall not be an integral part of the motor assembly, to allow for motor or gear changes dictated by system operation changes.

4) The motor shall be equipped with internal thermal contacts to protect against motor overload.

5) Motors shall be provided with space heaters for 120-volt, single phase operation of such number and wattage to prevent condensation on internal motor parts in all climatic conditions encountered.

c. Lost Motion Device

1) The operator shall have a built-in device that allows the motor to reach full speed before engaging the damper load when required by unseating applications.

d. Manual Operation

1) A metallic hand-wheel not less than 10 inches in diameter shall be provided for manual operation with arrow to indicate "open" rotation. The hand-wheel shall not rotate during motor operation thereby ensuring personnel safety. A seized motor shall not prevent manual operation. When in manual operation mode, the actuator shall remain in this mode until the motor is energized, at which time the actuator shall automatically return to electric operation without imparting any motion to the hand-wheel. Movement from motor operation to hand-wheel operation shall be accomplished by a positive, pad-lockable de-clutching lever, which mechanically disengages the motor and related gearing. It
shall be impossible for simultaneous manual and motor operations to occur. Friction type de-clutch mechanisms are not acceptable.

e. Position Limit Switches (Internal)

1) Internal position limit switches for each operator shall be provided for open and closed indication of the damper meeting the requirements of NEMA ICS. These limit switches are in addition to blade mounted external limit switches. Position limit switches and associated gearing shall be an integral part of the damper operator. Limit switch gearing shall be of the intermittent type, made of bronze or stainless steel, grease lubricated, and totally enclosed to prevent dirt and foreign matter from entering the gear train. Limit switch contacts shall be heavy duty and silver-plated with wiping action.

2) Switches shall be field adjustable, allowing for trip points from fully open to fully closed positions of damper travel. They shall not be subject to breakage or slippage due to over-travel.

3) Switch design shall permit visible verification of switch position without disassembly.

4) Switch compartment shall have not less than four independently adjustable single pole, double throw limit switches to permit any desired circuit design.

f. Switch Contact Ratings

1) The position limit switch contacts shall be rated at not less than 5 amperes, 120 volts, 60 Hertz.

g. Control Compartment Heater

1) The control compartment shall be provided with space heaters for 120-volt, single phase, operation of such number and wattage to prevent condensation on internal control compartment parts in all climatic conditions encountered in the damper locations.

h. Construction

1) The operator shall possess the following features: Housing castings shall be high strength aluminum alloys or cast iron. The electrical enclosures shall be rated NEMA 4. All external exposed surfaces and hardware shall be completely anti-corrosive. The operator shall incorporate double reduction-hardened worm and high strength bronze worm gears as prime power transmission elements. Mechanical adjustable stops shall be provided for 90-degree rotation plus or minus 10 degrees. It shall have a built-in mechanical dial position indicator. All switches, motor, and heater shall be pre-wired to terminal strips inside of access cover of actuator allowing for electrical field wiring. Shafts, gears and other rotating components shall be supported on heavy duty, anti-friction bearings to provide the highest possible efficiency.
i. External Wiring Terminal Box

1) Provide each damper with one external wiring terminal box. Provide all necessary interlocking conduits, fittings and wiring within the damper assembly and terminate all wiring in one common terminal box connection to Sound Transit’s external wiring.

j. Lubrication

1) All rotating power train components shall be immersed in grease with provisions for inspection and re-lubrication without disassembly. Lubricants shall be suitable for ambient conditions of minus 20 degrees F to 200 degrees F. Adequate seals shall be provided on all shafting. In addition the lubricant shall provide for continued operation of the motor with air temperature of 482 degrees F flowing over the motor for a minimum of 1 hour.

2) One heavy-duty grease gun with a fully loaded cartridge of the approved grease shall be furnished for each damper operator to lubricate the power train components.

k. Nameplate

1) Each damper operator shall be provided with a stainless steel nameplate and connection diagram. Nameplate shall be stamped with the name of the damper operator manufacturer, the manufacturer’s address, unit model number, the nominal motor horsepower, input voltage, full load current, phase, unit operating time for 90-degree movement of output shaft, locked rotor indicating code letter, maximum output torque, running torque, damper operator serial number, and shop order number. Each nameplate and connection diagram shall be located in a conspicuous position after field installation.

3. Painting:

a. All surfaces of damper operator, damper operator base, and damper frame stiffeners shall be painted except damper blades, damper shafts, damper nameplate, damper operator nameplates, and machined surfaces to receive appurtenances in accordance with the requirements specified in Article 2.08, Painting, herein.
B. Design Criteria:

1. Ductwork shall be fabricated in accordance with approved shop drawings, as specified herein and as shown on the Contract Drawings.

2. Ductwork shall be fabricated in multiple sections. The sections shall be of such size that can be brought into the fan chambers through the access provided; and facilitate handling, erection, and disassembly.

3. Ductwork shall be stiffened with reinforcing angles to be free from excessive vibration at all fan speeds or pressures within the operating range.

4. Ductwork shall be designed to produce rigid units to withstand imposed loads encountered during transportation, handling, erection, and operation.

5. Ductwork shall be designed to be airtight while withstanding a minimum positive or negative pressure differential of 10 inches of water without exceeding allowable stresses or fan shut-off pressure against a closed damper, which ever is higher.

6. Ductwork shall be designed to withstand a minimum pressure differential of 10 inches of water, positive or negative, without exceeding deflection limitations of L/360 for structural members. "L" is defined as span length.

7. Access doors shall be of steel construction and shall be provided on both sides of ductwork where indicated. Each access door shall have a clear opening size not less than 30 inches in width by 36 inches in height. Access doors shall be provided with not less than 1/4-inch thick gaskets to insure air-tight construction.

8. Ductwork, access doors and all gaskets shall be designed to withstand an ambient temperature not less than 482 degrees F for one hour of operation.

9. The ductwork shall be furnished complete with all structural members, supports, legs and mounting plates. The manufacturer shall furnish all supports.

10. Ductwork that passes through fire rated walls shall meet requirements of NFPA 221 and NFPA 91.

11. Duct material and construction shall conform to NFPA 91.

C. Materials:

1. Steel Sheet: Steel sheet for ductwork shall be hot or cold rolled steel sheet conforming to the requirements of ASTM A36 not less than No. 10 USSG.
   a. Fairings shall be fabricated from not less than No. 10 USSG sheet steel.

2. Steel Shapes, Angles, and Plates:
   a. Steel for ductwork and intermediate supports shall conform to the requirements of ASTM A36 with a minimum yield stress equal to 36 ksi.
   b. Steel angles for ductwork reinforcement and companion connections between ductwork and other equipment shall be not less than 3 inches by 3 inches by 1/4 inch thick, unless otherwise indicated on the Contract Drawings.
c. Corner angles for connecting side sheets of ductwork shall be not less than 1-1/2 inches by 1-1/2 inches by 1/4 inch thick.

3. Lifting Lugs: A minimum of two steel lifting lugs shall be provided on the exterior of each ductwork section.

4. Heat Resistant Sealant: After assembly, all air leaks shall be sealed with a heat resistant sealant formulated to perform at temperatures ranging from -15 to 500 degrees F for continuous operation with an intermittent peak temperature capacity of 600 degrees F.

5. Temperature Resistant Gasket: Temperature resistant gasket shall contain carbon fiber with suitable matrix to perform at 482 degrees F for a minimum of 1 hour. Gasket shall have a minimum width of 3 inches and a minimum thickness of 1/4 inch unless otherwise noted on the Contract Drawings. Gasket shall be installed according to manufacturer’s recommendations.

D. Construction:

1. Ductwork shall be constructed in accordance with SMACNA Industrial Duct Construction Standards.

2. Fabrication:
   a. The ductwork side sheets shall be connected together by welding to corner angles. All seams shall be of the continuous welded types only.
   b. The section connections shall be well fitted and the sections shall be bolted together.
   c. In addition to structural welds all exposed edges of sheet forming the housing shall be continuously welded.
   d. The work shall be fabricated from new material, free from mill scale, flake, rust, and mill pitting.
   e. The work shall be formed and finished without distortion to shape and size with sharp angles and lines.
   f. Metal work bent by shearing or punching cannot be used.
   g. Holes shall be punched or drilled for fasteners. Hole spacing for connection flange angles shall be not more than 8 inches center to center and holes shall be equally spaced.
   h. Re-entrant corners shall be shaped notch free.
   i. Edges of work shall be ground smooth.
   j. Terminating ends of reinforcing angles shall be rounded or beveled.
   k. Brackets, access doors, lugs, and similar accessories shall be included as part of the metal work.
   l. Steel sheet for ductwork shall be welded to angles with continuous fillet welds at top of leg and at the base unless otherwise indicated on the Contract Drawings.
m. Each ductwork section flange shall be match marked with stencils or embossed in a conspicuous location for identification during installation in the fan chambers.

n. All welding shall be in accordance with the latest edition of AWS Welding Code.

3. Painting: All surfaces of the duct work inside and outside, including the fairings and all supports shall be painted in accordance with the requirements specified in Article 2.08, Painting, herein.

### 2.07 SOUND ATTENUATORS

#### A. General:

1. All sound attenuators shall be product of a single manufacturer whose name shall appear on the product and product data.

2. Sound attenuator unit shall consist of shell and attenuator splitters assembled on site to form an overall sound attenuator of the dimensions shown on the Contract Drawings.

3. This portion of the specification describes the requirements for furnishing and installing sound attenuators on the emergency fans and smoke exhaust fans as shown on the Contract Drawings and as specified herein.

4. As a minimum, the sound attenuators shall be square or rectangular in the cross section and length as shown on the Contract Drawings and shall be designed for the design goal specified in Article 2.07.B, Design Criteria, herein. The modules in a given unit shall be equal to overall length of the sound attenuator.

#### B. Design Criteria

1. The Contractor shall furnish sound attenuation so that the fan/motor unit and all auxiliary equipment combined shall be guaranteed not to exceed the following sound pressure decibel levels when all fans in the fan room are operating simultaneously in the exhaust mode.

   a. At station platform level: The noise at platform level shall not exceed 75 dBA as required by Sound Transit Link Design Criteria Manual, dated November 2005, Chapter 3 Environmental, Table 3-5.

   b. At grade level above the tunnel:

   c. The design goals for noise attributable to fans shall be according to following requirements.
Noise From Transit System Ancillary Facilities – Leq (dBA)

<table>
<thead>
<tr>
<th>District of Sound Source</th>
<th>District of Receiving Property Within the City of Seattle</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Residential (dBA)</td>
</tr>
<tr>
<td>Residential</td>
<td>55/45</td>
</tr>
<tr>
<td>Commercial</td>
<td>57/47</td>
</tr>
<tr>
<td>Industrial</td>
<td>60/50</td>
</tr>
</tbody>
</table>

Notes:

1. The noise level limits are presented for (daytime)/(nighttime). Daytime is 7 a.m. to 10 p.m and nighttime 10 p.m. to 7 a.m.
2. For intermittent noise sources add 10 dB. Intermittent noise is defined as a noise that lasts for a cumulative period of less than 10 minutes every hour.
3. The noise limits shall be reduced by 5 dBA if the noise has pure tones or contains an audible screech, whine, or hum, or contains information content such as music or public address system announcements.

2. All acoustical treatment of the fan assemblies is required to meet the above limits, including, but not limited to, the fan housing external acoustical insulation and outlet duct silencers supplied by the Contractor.

C. Performance

1. For the sound attenuators shown on the drawings of the emergency fans and smoke exhaust fans, the minimum dynamic insertion loss with airflow in the exhaust mode shall be submitted to meet “Design Criteria” indicated above and for maximum sound power levels for fans at rated speed and design duty point.
   a. At an air density of 0.082 lbf/ft³, the pressure losses with design flow shall not exceed values shown in equipment schedules.

2. The self generated sound of any module corrected for face area adjustment factors shall not be greater than the sound power level of the fan unit minus the dynamic insertion loss of the element in any octave band.

3. Independent Testing Laboratory tests shall be performed on scale models that are representative of the units to be supplied. See Article 1.07, Factory Tests and Inspections, herein, for a description of the required shop testing.

D. Materials

1. Sound attenuator shell is defined as a site or factory assembled sheet metal casing into which splitters are installed on site. The shells of the silencers shown on the Contract Drawings shall be fabricated from not less than No. 10 USSG ASTM A240, Type 304 stainless steel.
   a. Flanges and stiffeners shall be of not less than 1/4-inch Type 304 stainless steel bent plate or ASTM A276 stainless steel angles.
2. All splitters including the nose and tail and the face sheets shall be fabricated from not less than 18 USSG ASTM A293 or ASTM A240, Type 304 stainless steel perforated as required to provide acoustic transparency.

3. The filler material shall be inorganic mineral or glass fiber of sufficient density to obtain the required acoustic attenuation. The material shall be inert, vermin-proof and resistant to high humidity conditions. The combustion rating of the material, when tested in accordance with NFPA 255/UL Standard 723, shall not be greater than the following:
   a. Flame Spread Classification 20
   b. Smoke - Developed Rating 20

4. The filler material shall be protected with glass fiber cloth and stainless steel screen.

5. Noses directly exposed to rain and snow shall have no perforations.

6. All components and the entire assembly shall be capable of maintaining its structural integrity and air flow capacity at air flow temperatures of 482 degrees F for one hour.

E. Construction:

1. The sound attenuators shall be constructed in accordance with SMACNA Industrial Duct Construction Standards. Shells shall be sufficiently modularized to allow for ease of disassembly, installation, and reassembly. Sound-attenuators shall be furnished with flanges with minimum of 3 inches width at both ends, to permit the units to be rigidly bolted to adjacent components. Flanges shall be bolted to the outer periphery of the casings unless otherwise indicated. All longitudinal seams shall be of the continuous welded types only. All angles shall be mechanically fastened at corners. Gaskets or sealants shall be capable of withstanding an ambient temperature of 482 degrees F for a period of 1 hour without degradation of sealing ability.

2. The construction shall be for a minimum positive or negative pressure differential of 10 inches of water gauge or fan shut-off pressure against a closed damper, which ever is higher without exceeding allowable stresses.

3. Sound-attenuating modules shall be designed to be readily disassembled and reassembled in the field. Sound-attenuators shall be designed to be capable of operating and performance requirements specified herein, when the elements are disassembled and reassembled in accordance with the explicit, written instruction of the manufacturer of the elements.

4. The sound attenuators shall be furnished complete with all structural members, supports, legs and mounting plates. The manufacturer shall furnish all floor supports. Structural supports shall be designed to be bolted to shells. The Contractor shall provide clips, fasteners, and sealing material for sealing the attenuator to the wall openings where applicable.

5. The structural members shall be made of minimum 1/2-inch ASTM A240 bent plate or ASTM A36 carbon steel structural shapes and hot-dip galvanized after fabrication.

6. All welding shall be in accordance with the latest edition of AWS Welding Code.
7. The sound attenuators shall be installed in accordance with the installation procedures provided by the manufacturer.

F. Nameplates:

1. Each sound-attenuator unit shall be provided with a stainless steel nameplate permanently stamped with the name and address of the manufacturer, Contractor's identification number, model type, shop order number and serial number, and Sound Transit's attenuator designation number. The nameplate shall be securely attached to the exterior of the attenuator unit in a conspicuous location.

2. The forward direction of airflow shall be permanently marked on each sound attenuator module in a location conspicuous after installation.

2.08 PAINTING

A. Materials:

1. General:

a. This Section describes the requirements for furnishing and applying paint on tunnel ventilation equipment as specified herein.

b. The Work includes shop painting the surfaces specified in the several specification Sections herein.

c. All paint material provided shall be from one source.

d. All paint material shall be Volatile Organic Compound (VOC) compliant.

e. Paint/finishes shall be factory-applied and shall be certified by the manufacturers of the finishing materials to be capable of withstanding exposure to an ambient temperature of 482 degrees F for a minimum of one hour without producing smoke or toxic fumes.

f. Paint colors shall be as selected by the Resident Engineer.

g. Machined surfaces not requiring painting shall be provided with a coating of suitable anti-corrosion compound before leaving the place of manufacture.

h. Galvanized sheet metal shall not be painted.

2. Primer paint material shall be Carboguard Carbozinc 11HS, a high solids inorganic zinc rich primer or acceptable substitute.

B. Construction:

1. Surface Preparation:

a. Surfaces except Surfaces of Motors

   1) Surfaces, except surfaces of motors, to receive primer paint material shall be prepared in accordance with the requirements of SSPC SP-6.
2) The minimum height of profile after completion of blast cleaning shall be 1.5 mils.

b. Surfaces of Motors: Surfaces of motors to receive primer paint material shall be prepared in accordance with the requirements of SSPC SP-3.

2. Number of Coats: Surfaces specified to receive paint shall receive one coat of primer paint material, one coat of intermediate paint material, and one coat of topcoat paint material.

3. Dry Film Thickness:
   a. Primer: The minimum dry film thickness of the primer coat shall be 3 mils.
   b. Intermediate Coat: The minimum dry film thickness of the intermediate coat shall be 3 mils.
   c. Topcoat: The minimum dry film thickness of the topcoat shall be 3 mils.

4. Paint Application: Primer, intermediate and topcoat paint materials shall be applied in accordance with the requirements of the paint material manufacturer's printed paint application instructions and in accordance with the applicable non-conflicting requirements of SSPC PA-1.

5. Coating Thickness Measurement:
   a. As specified herein, the applied and cured paint film shall be tested to determine the dry film thickness.
   b. Measurement of dry film thickness shall be in accordance with the requirements of SSPC PA-2.

6. Corrective Painting: Surfaces, which after painting and after installation of components are not as specified, shall be re-cleaned, re-primed and re-painted as may be required until the specified coating requirements have been obtained.

2.09 FLEXIBLE CONNECTIONS

A. General
   1. Flexible connections shall be provided where called for on the Contract Drawings. Each flexible connection shall consist of a “flat belt” fabric connector and fabric securing clamps.

B. Materials
   1. Fabric shall be suitable for a temperature of 482 degrees F for one hour of operation.
   2. The flat belt elastomeric element shall be of gas tight construction, shall have completely sealed edges and shall be devoid of stitching.
   3. The fabric material shall be flexible, flame retardant, abrasion resistant, and shall withstand without deleterious effect, saturation with grease and oil.
   4. The flat belt element shall be a minimum of 9 inches long.
5. Clamping bars shall be made of 16 USSG Type 316L SS and shall be 3 inches wide. Clamping bars shall have minimum 2 inches by 2 inches by 3/16 inch Type 316L SS angle cleats welded at or near each end.

6. Connection flanges shall be fabricated from structural steel angle sections conforming to the requirements of Specifications for Structural Steel, ASTM A36. Companion angle sections shall be not less than three inches by three inches by 1/4-inch thick. Frame shall be welded with full penetration butt welds. Companion flanges shall have punched or drilled holes sized to receive the size bolts required by component being connected. Companion flanges shall be hot-dip galvanized after fabrication.

7. One end of each section of clamp bar shall be formed to allow for a minimum of 2 inches of overlap.

C. Construction

1. The entire assembly shall be designed to be airtight and shall be of sufficient strength to withstand a pressure of ± 10 inches water gauge or fan shut-off pressure against a closed damper, which ever is higher.

2. Flexible connections shall be designed to allow radial, axial, rotational, and lateral movement of fan housings resulting from expansion, contraction, and dynamics of fan operation, without unnecessary slack in fabric connector material.

3. Flexible connections shall be designed in accordance with SMACNA Industrial Duct Construction Standards.

2.10 COMPANION FLANGES AND MOUNTING FRAMES

A. General

1. Companion flanges shall be provided for connecting dampers, ductwork, sound attenuators and screen guards to concrete floor or concrete wall openings.

2. Mounting frames shall be provided for connecting dampers, ductwork, sound attenuators and screen guards to CMU wall openings.

3. Companion flanges and mounting frames shall be as shown on Contract Drawings.

4. Companion flanges and mounting frames shall be fabricated from structural steel conforming to the requirements ASTM A36. Flanges and frames shall be welded with full penetration butt welds.

5. Companion flanges and mounting frames shall be provided with bolt holes matching to bolt hole pattern of associated dampers, ductwork, sound attenuators and screen guards.

6. Bolts and nuts shall be provided according to Article 2.13, Hardware, herein.

7. Companion flanges and mounting frames shall be hot-dip galvanized. The galvanizing shall conform to ASTM A123 and shall withstand an eight-dip Preece test in accordance with ASTM A239.
2.11 SCREEN GUARDS
A. Screen guards shall be provided where indicated and on tunnel side of tunnel dampers. Screen guards shall be fabricated of not less than No. 10 Stubs Iron Wire Gauge, steel wire. Guards shall have rigid flanges designed to permit the guards to be bolted to the mating companion flanges or to floor or wall openings. Screen guards shall be provided with reinforcement angles with minimum structural angle size of 1 ½ inch by 1 ½ inch by 3/16 inch thick. Mounting and construction shall be designed for a minimum of positive or negative 16 inches water gauge. The guards, including the flanges, shall be hot-dip galvanized after fabrication. Mesh size shall be 2 inches by 2 inches. The galvanizing shall conform to ASTM A123 and shall withstand an eight-dip Preece test in accordance with ASTM A239.

2.12 GASKETS
A. Minimum thickness of gaskets shall be 1/4 inch and width of gasket shall be same as flange width. Gaskets shall be capable of withstanding an ambient temperature of 482 degrees F for a period of one hour without degradation of sealing ability and without emitting toxic or noxious fumes. Gaskets shall be provided at following locations;
1. Between dampers and companion flanges/mounting frames
2. Between ductwork and/or sound attenuators and companion flanges/mounting frames
3. Between wall opening and/or ductwork and sound attenuators
4. Between sound attenuator and flexible connections
5. Between transitions and flexible connections
6. Between transitions and fans
7. Between fans and flexible connections
8. Between transitions and sound attenuators.

2.13 HARDWARE
A. Fasteners:
1. Positive locking devices shall be provided for all nuts and bolts located within the airstream.
2. In accessible areas, fasteners shall be hexagonal head bolts with hexagonal nuts, provided with heavy-duty lock washers.
3. In inaccessible areas, fasteners shall be hexagonal head tap bolts, provided with heavy duty lock washers.
4. Bolts shall be not less than 1/2 inch in diameter unless otherwise indicated.
5. Bolts and tap bolts shall be stainless steel and shall conform to the requirements of ASTM A193, Grade B8M or B8MA, equivalent to AISI Type 316 SS, with suitable lock washers.
6. Nuts for use on the axial fans shall be stainless steel and shall conform to the requirements of ASTM A194, Grade 2H, equivalent to AISI Type 316.
low torque sealing application and at connecting flanges between ductwork sections or for connecting duct work to sound attenuators and dampers, shall be ASTM A194, Grade 8M, Type 316 SS.

7. Lock washers shall be stainless steel, equivalent to AISI Type 316 and shall conform to the requirements of ASME B18.21.1.

B. Anchor Bolts:

1. Anchor bolts shall be Type 316 SS Hilti Kwik Bolt II, Rawl-Stud, Maxi-Bolt, or approved equal and shall be fitted with recommended lock washers.

2. Anchor bolts shall conform to the requirements of ASTM A193, Grade B8M or B8MA, equivalent to AISI Type 316 SS.

3. Anchor bolts shall not be less than 5/8 inch in diameter.

C. Supports:

1. Design equipment and ductwork supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2. Design seismic supports according to criteria shown in Article 1.03, General Requirements, herein.

3. Obtain approval for support design from Sound Transit.

4. Fabricate and install supports as required for the application and as shown in Contract Drawings.

5. Steel supports shall be fabricated from structural steel conforming to ASTM A36.

6. Supports shall be hot-dip galvanized. The galvanizing shall conform to ASTM A123 and shall withstand an eight-dip Preece test in accordance with ASTM A239.

7. Submit support calculations according to Article 1.04, Submittals, herein.

2.14 ELECTRICAL REQUIREMENTS INCLUDING CABLES AND CONDUITS

A. Refer to Division 26, Electrical.

PART 3 - EXECUTION

3.01 CONSTRUCTION METHODS

A. General:

1. These Contract Specifications describe the requirements for installation of the emergency fan and smoke fan assemblies in the fan room as shown on the Contract Drawings and as specified herein.

2. The work includes installation of the emergency fans, smoke exhaust fans, fan motors and associated adjustable fan-motor auxiliaries, fan dampers, bypass dampers and tunnel dampers, ductwork, sound attenuators, and checking the balancing of fan wheels after installation.
3. The work also includes providing at the site the services of an erection superintendent as specified in Article 1.03.C, General Requirements, Supervision of Tunnel Ventilation Equipment Installation, herein.

4. The erection superintendent shall supervise the installation of the ventilation equipment and shall be present when portions of the work of installation of ventilation equipment are in progress.

5. Field testing of tunnel ventilation equipment shall be performed under the supervision of the erection superintendent.

B. Methods:

1. Lubrication: The lubricant recommended shall be furnished and applied immediately after installation to all components, requiring lubrication in amounts sufficient to provide complete initial lubrication.

2. Fan Impellers: Fan impellers for the emergency and smoke exhaust fans shall be balanced by the Contractor to provide less than 2 mil peak to peak maximum vibration displacement at each fan bearing at all speeds up to and including the maximum design operating speed.

3. Fan Housings:
   a. Install fan housings in accordance with accepted working drawings. Housing alignment work shall be square and true.
   b. Install bolts where shown and where necessary for fastening work in place.

4. Fan Dampers and Tunnel Dampers:
   a. The damper operator and hand wheel shall be in an accessible location to facilitate manual operation and routine maintenance.

5. Ductwork:
   a. Install ductwork between dampers and sound attenuators and outlets of the emergency fans and smoke exhaust fans and sound attenuators as shown on the Contract Drawings.

6. Electrical Cable and Conduits:
   a. Install interconnecting power and control wiring and raceways in accordance with accepted working drawings.
   b. Installation methods shall be in accordance with the requirements specified in the appropriate Sections of these Contract Specifications.

7. The motor space heaters shall be energized within 24 hours after the fans and the damper operators are delivered to a temporary storage place if the installation site is not ready. For fans waiting permanent power on site, temporary power shall be provided to the space heaters.

3.02 FIELD TESTING AND TRAINING

A. Description:
1. These Contract Specifications describe the requirements for field testing of the tunnel ventilation equipment installed and training as specified herein.

2. Field testing shall be performed when permanent electrical power and local controls can be provided for testing. Field testing of the tunnel ventilation equipment shall be performed after field testing of soft starters for fans and for fan damper control panels (FDCP) is complete as specified in Section 26 24 14, Motor Starters for Tunnel Fire Ventilation Fans, and Section 25 60 00, Building Management System.

3. The Contractor shall notify the Sound Transit’s representative in writing of all test dates not less than 14 days prior to tests, including the expected duration and sequence of testing.

4. Field testing shall not be performed without the presence of the Sound Transit’s representative, unless waived.

5. Axial fans, fan motors, motor controllers, dampers, and associated monitoring and control equipment shall be tested as specified herein.

6. Electrical energy required for field testing shall be furnished by the Contractor.

7. Field testing shall be provided at the expense of the contractor. Tests that fail shall be repeated upon corrections of all deficiencies as often as required until satisfactory performance is demonstrated, at no increase in Contract Price or Contract Time.

8. Field testing of tunnel ventilation equipment shall be performed under the supervision of the Manufacturer’s Representative with expertise in the field testing.

9. The Contractor shall provide the accepted field test instrumentation. After field testing is completed and accepted by Sound Transit’s representative, the field test instrumentation shall remain the property of the Contractor.

10. A copy of all tests and checks performed in the field, complete with meter readings and recordings, where applicable, shall be submitted for approval.

11. Provide calibration certificates for all field instrumentation used during testing. Calibration shall have taken place not more than 180 days prior to the tests. Calibration shall be traceable to the National Bureau of Standards.

B. Materials: Lubricants of the correct type and grade shall be provided where required.

C. Testing Requirements for the Emergency Fans, Smoke Exhaust Fans and Dampers:

1. Damper Tests:

   a. Each fan damper and tunnel damper shall be subject to rotation reversal tests. A cycle of rotation is defined as reversal from fully open to fully closed position, and then back to fully open. Each damper shall require five cycles of rotation.

   b. Damper blades and linkage shall operate smoothly and without binding.

   c. After completion of reversal tests, each damper operator shall be de-energized and checked to ensure that it is driven to its “fail-safe” position within 15 seconds after being de-energized.
2. Winding RTD and Fan Motor Bearing Vibration and RTD:
   a. Check that fan motor winding temperature RTD, fan motor bearing vibration and fan motor bearing temperature RTD controls are calibrated and operational for each fan. Accuracy for the fan motor winding temperature RTD, fan motor bearing vibration and fan motor bearing temperature RTD shall be according to Articles 2.03.C.1, Windings and 2.03.C.10, Motor Bearings, herein.

3. Fan Vibration Tests:
   a. Amplitude and frequency of radial and axial vibration shall be measured, recorded, and checked for conformity to these Contract Specifications. Defective bearings shall be replaced with new bearings and the fan(s) and/or motor(s) rechecked.
   b. After above vibration checks have proved successful, check that the fan and motor are fully operational and the entire fan/duct system is ready and cleared for fan operation.

4. Continuous Run Test:
   a. Operate each emergency fan individually for a period of one hour and in parallel with each other for a period of 1 hour in the supply and exhaust modes. Winding and bearing temperatures and vibration shall be recorded at 5-minute intervals during each hour of operation. The voltage, current, power factor, power input, and speed shall be recorded for each operating mode.
   b. Operate each smoke exhaust fan individually for a period of 1 hour and in parallel with each other for a period of one hour in the exhaust mode. Winding and bearing temperatures and vibration shall be recorded at 5-minute intervals during each hour of operation. The voltage, current, power factor, power input, and speed shall be recorded for each operating mode.
   c. The voltage, current, power factor, power input, and speed for emergency fans and smoke exhaust fans shall be compared to rated motor parameters and shall not exceed a tolerance of +/- 5 percent.

5. Airflow Tests:
   a. The Contractor shall use the bushings provided in the fan housing for a pitot tube traverse with a laboratory grade pitot tube. The airflow measurements shall be taken in both supply and exhaust mode of operation for the emergency fans and in exhaust mode for smoke exhaust fans. The airflow shall not be below values shown in equipment schedules for individual fans when operating in parallel with other fans.

6. Starting Test:
   a. Each fan shall be started and brought to the rated supply capacity four times in one hour. Each fan shall also be started and brought to the rated exhaust capacity four times in one hour. The starts shall be equally spaced within the hour. The motors shall not overheat nor shall the fans experience excessive vibration during this test.
b. In addition, each fan shall be started in the supply mode and run continuously for 30 minutes at which time it shall be switched to the exhaust mode and run for an additional 30 minutes, following which it shall be immediately switched back to the supply mode, run for an additional five minutes and turned off.

c. The voltage, current, power factor and power shall be continuously recorded. The motors shall not overheat or trip out during the test. Overheating temperature shall not exceed specified values in Article 2.03, Fan Motors, herein.

d. The voltage, current, power factor, power input, and speed for emergency fans and smoke exhaust fans shall be compared to rated motor parameters and shall not exceed a tolerance of +/- 5 percent.

7. Sound Tests:

a. Measure sound pressure level with emergency fans running individually in forward (exhaust) and reverse (supply) modes.

b. Measure sound pressure level with smoke exhaust fans running individually. Sound testing for smoke exhaust fans shall be performed separately.

c. Note fans that exceed specified sound pressure levels and make recommendation for reducing their sound pressure level to acceptable limits.

d. Sound pressure levels design goals for noise attributable to fans shall be according to Article 2.02.B Sound Requirements, herein.

8. Defects: During the tests, if any defects in equipment, installation, or deviance in initial submittals or analysis become evident, the defects shall be corrected and the tests re-run until satisfactory performance is obtained at no increase in the Contract Price or Contract Time.

9. Tunnel Airflow Tests:

a. The last portion of the field tests shall be the measurement of air movement within the tunnel produced by the ventilation system with all required fans operating. These measurements shall serve as a verification that the ventilation system would produce sufficient air movement in the tunnel/train annular area during a fire to satisfy emergency ventilation criteria.

b. The test shall include measurement of noise at property line and at platform level at a junction of tunnel and both platform ends attributed to the ventilation system.

c. These tests shall be performed by qualified personnel (employees of the Contractor or a Subcontractor) who have been approved by the Sound Transit. The overall responsibility for this measurement program shall belong to the Contractor.

d. The Sound Transit shall provide the Contractor with details on three locations for the measurements, the testing conditions (such as ventilation system operating requirements and the location of stopped trains), and the test results required for each location at least 180 days
prior to the scheduled date of test initiation. The entire tunnel cross section shall be traversed with a minimum of 36 traverse points in order to measure the average airflow (in cubic feet per minute) through the cross section. The measurements shall be accurate to plus or minus five percent and shall account for the effects of the tunnel portals, changes in horizontal curvature, and location and distance from the stopped train. Contractor shall make the necessary arrangements with the Sound Transit to schedule the tests and to use a stopped train during the actual testing period.

e. Submit to the Sound Transit for approval a written test program at least 90 days prior to the scheduled date of test initiation. This test program shall contain, as a minimum, the resumés of the key personnel participating in the test phase, the specific make and model numbers of the test equipment to be used, and a general procedure to be followed for the set-up of equipment and for the sampling, recording and reduction of the test data.

f. Provide the Sound Transit with the measured test results. If the Sound Transit determines that the measured air velocities are less than the required "cold" air velocities, the Contractor will be notified in writing to increase the blade angles in order to produce the required tunnel airflow velocities. If the increased fan air flows cause overloading of the fan motors, the Contractor shall advise the Sound Transit in writing on the extent of the overload. The Sound Transit shall provide the Contractor with a written list of the appropriate equipment modifications that the Contractor shall be responsible to perform, if any. The field measurements shall then be repeated in order to verify that the required tunnel airflows have been achieved.

g. Permissible noise levels shall not exceed as specified in Article 2.07, Sound Attenuators, herein.

h. The Sound Transit shall be notified in writing at least two weeks prior to the initiation of this testing phase in order to coordinate the use of train(s) and to program the appropriate ventilation system operation.

10. Records: Records shall be compiled of the results of all tests. The records shall include defects occurring during testing and corrective measures taken.

11. Training: Provide the services of a factory-authorized service representative to demonstrate the system and train Sound Transit’s maintenance personnel as specified in Article 1.05, Quality Control, herein.

12. Other tests listed elsewhere in these Contract Specifications.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes metal, rectangular ducts and fittings for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 07 84 00, Firestopping
2. Section 23 08 00, Commissioning For HVAC System
3. Section 23 33 00, Air Duct Accessories

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. National Fire Protection Association (NFPA)
   a. NFPA 90A Installation of Air Conditioning and Ventilating Systems
   b. NFPA 90B Installation of Warm Air Heating and Air-Conditioning Systems

   a. ASTM A653 Steel Sheet, Zinc-coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process
   b. ASTM C920 Elastomeric Join Sealants
   c. ASTM A 36 Carbon Structural Steel

3. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
   a. SMACNA HVAC duct construction standards – metal and flexible
   b. SMACNA Duct cleanliness for new construction

4. Underwriters Laboratory (UL)
   a.) UL 723 Tests for Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Shop Drawings: Show fabrication and installation details for metal ducts.
   1. Penetrations through fire-rated and other partitions.
   2. Duct accessories, including access doors and panels.

1.04 QUALITY ASSURANCE

A. NFPA Compliance:
   1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
   2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.01 GENERAL

A. The sheet metal ducts specified in this section shall not be used in the tunnel ventilation equipment systems.

2.02 MANUFACTURERS

A. In other Part 2, Existing Conditions, Sections where titles below introduce lists, the following requirements apply to product selection:

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

2.03 SHEET METAL MATERIALS

A. Comply with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.04 SEALANT MATERIALS

A. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.

B. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

C. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
D. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

F. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.05 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Use expansion bolt for concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

2. Exception: Do not use powder-actuated concrete fasteners.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

2. Strap and Rod Sizes: Comply with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Galvanized-steel shapes and plates complying with ASTM A 36/A 36M.

2.06 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.

2. Deflection: Duct systems not to exceed deflection limits according to SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer’s guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Available Manufacturers:
   a. Ductmate Industries, Inc.
   b. Nexus Inc.
   c. Ward Industries, Inc.
C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Available Manufacturers:
   a. Ductmate Industries, Inc.
   b. Lockformer.

2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.

3. Longitudinal Seams: Pittsburgh lock sealed with non-curing polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

PART 3 - EXECUTION

3.01 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts: 2-inch wg.

2. Supply Ducts (before Air Terminal Units): 3-inch wg.


7. All Duct within the tunnel shafts shall be both a negative and positive pressure: 10 inch wg.

3.02 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," unless otherwise indicated.

B. Install ducts with fewest possible joints.

C. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of three screws in each coupling.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

I. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

J. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

K. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

L. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

M. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Section 23 33 00, Air Duct Accessories.

N. Firestopping materials and installation methods are specified in Section 07 84 00, Firestopping.

O. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

3.03 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

1. For pressure classes lower than 2-inch wg, seal transverse joints.

B. Seal ducts before external insulation is applied.

3.04 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
3.05 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Section 23 33 00, Air Duct Accessories.

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.06 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Metal Ducts systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the following non-tunnel ventilation equipment. Non-tunnel ventilation equipment is also specified in Section 23 09 00, Instrumentation and Control for HVAC.

1. Backdraft dampers
2. Volume dampers
3. Fire dampers
4. Ceiling fire dampers
5. Smoke dampers
6. Combination fire and smoke dampers
7. Turning vanes
8. Duct-mounting access doors
9. Flexible connectors
10. Flexible ducts
11. Duct accessory hardware

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 23 05 13, Common Motor Requirements for HVAC Equipment
2. Section 23 05 93, Testing, Adjusting and Balancing for HVAC
3. Section 23 05 53, Identification for HVAC Piping and Equipment
4. Section 23 08 00, Commissioning For HVAC System
5. Section 23 09 00, Instrumentation and Control for HVAC

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society for Testing and Materials International (ASTM)
a. ASTM B221 Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
b. ASTM B209 Aluminum and Aluminum Alloy Sheet and Plate
c. ASTM A653/A653M Steel Sheet, Zinc-coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process
d. ASTM A480/A480M General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

2. National Fire Protection Association (NFPA)
a. NFPA 90A Installation of Air Conditioning and Ventilating Systems
b. NFPA 90B Installation of Warm Air Heating and Air-Conditioning Systems

3. Underwriters Laboratory (UL)
a. UL 555 Safety Fire Dampers
b. UL 555S Safety Smoke Dampers
c. UL 181 Factory-Made Air Ducts and Connectors

4. Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA)
a. SMACNA HVAC Duct Construction Standards–Metal and Flexible

1.03 SUBMITTALS

A. Procedure: Section 01 33 00, Submittal Procedures.

B. Product Data: For the following:
   1. Backdraft dampers.
   2. Volume dampers.
   3. Fire dampers.
   4. Ceiling fire dampers.
   5. Smoke dampers.
   6. Combination fire and smoke dampers.
   7. Turning vanes.
   8. Duct-mounting access doors.
   10. Flexible ducts.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Special fittings.


3. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.


1.04 QUALITY ASSURANCE


PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

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

2.02 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards–Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653 and having G90 coating designation; mill-phosphatized ducts finish for duct surfaces exposed to view.

C. Stainless Steel: ASTM A 480.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.


F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 BACKDRAFT DAMPERS

A. Available Manufacturers:

1. Air Balance, Inc.

2. American Warming and Ventilating.
3. CESCO Products.
4. Duro Dyne Corp.
5. Greenheck.
7. Prefco Products, Inc.
8. Ruskin Company.

B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: 0.052-inch thick, galvanized sheet steel, with welded corners and mounting flange.

D. Blades: 0.050-inch thick aluminum sheet.

E. Blade Seals: Neoprene.

F. Blade Axles: Galvanized steel.

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

2.04 VOLUME DAMPERS

A. Available Manufacturers:

1. Air Balance, Inc.

2. American Warming and Ventilating.

3. Flexmaster U.S.A., Inc.


5. METALAIRE, Inc.

6. Nailor Industries Inc.

7. Penn Ventilation Company, Inc.

8. Ruskin Company.


B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
C. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.

2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.


5. Tie Bars and Brackets: Galvanized steel.

D. Jackshaft: 1-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.05 FIRE DAMPERS

A. Available Manufacturers:

1. Air Balance, Inc.

2. CESCO Products.


5. METALAIRE, Inc.

6. Nailor Industries Inc.

7. Penn Ventilation Company, Inc.

8. Prefco Products, Inc.


B. Fire dampers: labeled according to UL 555.

C. Fire Rating: Three hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
   2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Fusible Links: Replaceable, 212 degrees F rated.

2.06 CEILING FIRE DAMPERS

A. Available Manufacturers:
   1. Air Balance, Inc.
   2. CESCO Products.
   5. METALAIRE, Inc.
   6. Nailor Industries Inc.
   7. Penn Ventilation Company, Inc.
   8. Prefco Products, Inc.

B. General Description: Labeled according to UL 555C; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL’s "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Fusible Links: Replaceable, 212 degrees F rated.

2.07 COMBINATION FIRE AND SMOKE DAMPERS

A. Available Manufacturers:
   1. Air Balance, Inc.
2. CESCO Products.
4. Nailor Industries Inc.
5. Penn Ventilation Company, Inc.
6. Ruskin Company.

B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.

C. Fusible Links: Replaceable, 212 degrees F rated.

D. Frame and Blades: 0.064-inch-thick, galvanized sheet steel.

E. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application.

F. Dampers behind Wall Grilles: Located damper out-of-the-wall and damper motor in airstream to provide access through the wall grille.

G. Damper Motors: Modulating and two-position action.
   1. Comply with requirements in Section 23 05 13, Common Motor Requirements for HVAC Equipment.
   3. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
   4. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F.
   5. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
   6. Electrical Connection: 115 V, single phase, 60 Hz.

2.08 TURNING VANES

A. Fabricate to comply with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch-wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Available Manufacturers:
   a. Ductmate Industries, Inc.
   b. Duro Dyne Corp.
C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.09 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Available Manufacturers:
   a. American Warming and Ventilating.
   b. CESCO Products.
   c. Ductmate Industries, Inc.
   d. Flexmaster U.S.A., Inc.
   e. Greenheck.
   g. Nailor Industries Inc.
   h. Ventfabrics, Inc.
   i. Ward Industries, Inc.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Provide number of hinges and locks as follows:
   a. Less Than 12 Inches Square: Secure with two sash locks.
   b. Up to 18 Inches Square: Two hinges and two sash locks.
   c. Up to 24 by 48 Inches: Three hinges and two compression latches.
   d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

1. Available Manufacturers:
   a. Ductmate Industries, Inc.
   b. Flexmaster U.S.A., Inc.

2. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
E. Insulation: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.10 FLEXIBLE CONNECTORS

A. Available Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Corp.
   3. Ventfabrics, Inc.

B. General Description: Flame retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 degrees F.

2.11 FLEXIBLE DUCTS

A. Available Manufacturers:
   1. Flexmaster U.S.A., Inc.
   2. Hart & Cooley, Inc.

B. Noninsulated-Duct Connectors: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 20 to plus 210 degrees F.

C. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 degrees F.

D. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.
2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.
2. Downstream from volume dampers, turning vanes, and equipment.
3. Adjacent to fire, smoke, and combind fire smoke dampers, providing access to reset or reinstall fusible links.
4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
5. On sides of ducts where adequate clearance is available.

I. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.

J. Install the following sizes for duct-mounting, round access doors:
   1. One-Hand or Inspection Access: 8 inches in diameter.
   3. Head and Hand Access: 12 inches in diameter.

K. Label access doors according to Section 23 05 53, Identification for HVAC Piping and Equipment.

L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

M. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect diffusers or light troffer boots to low pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with draw bands.

Q. Install duct test holes where indicated and required for testing and balancing purposes.

3.02 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.03 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Air Duct Accessories systems and equipment. See Section 23 08 00 Commissioning of HVAC Systems for commissioning requirements pertaining to the work of this Section.
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the specifications for the following:
   1. In-line centrifugal fans.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 03 30 00, Cast-in-Place Concrete
   2. Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment
   3. Section 23 08 00, Commissioning for HVAC
   4. Section 23 33 00, Air Duct Accessories
   5. Section 26 05 25, Wire and Cable
   6. Section 26 05 26, Grounding and Bonding Electrical Systems
   7. Section 26 29 13, Enclosed Controllers

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.
   1. National Fire Protection Association
      a. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems"

1.03 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Field quality-control test reports.

D. Operation and maintenance data.
1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory to authorities having jurisdiction, and marked for intended use.

B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

C. UL Standard: Power ventilators shall comply with UL 705.

PART 2 - PRODUCTS

2.01 IN-LINE CENTRIFUGAL FANS

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

2. American Coolair Corp.
3. Ammerman; General Resource Corp.
4. Bayley Fans; a division of Lau Industries, Inc.
5. Breidert Air Products
6. Carnes Company HVAC
7. FloAire
8. Greenheck
9. Hartzell Fan, Inc.
10. JencoFan; Div. of Breidert Air Products
11. Loren Cook Company
12. Madison Manufacturing
13. Penn Ventilation
14. Quietaire Corporation

C. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor, drive assembly, mounting brackets, and accessories.

D. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
E. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

F. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

G. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

H. Accessories:
   1. Motor Starter: Magnetic full-voltage type with heavy-duty relay contacts, and in accordance with the requirements of Section 26 29 13, Enclosed Controllers.
   2. Motor Variable Frequency Drive: shall be as specified in 26 29 13, Enclosed Controllers.
   3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   5. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.02 MOTORS
   A. Comply with requirements in Section 23 05 13, Common Motor Requirements for HVAC Equipment.
   B. Enclosure Type: Totally enclosed, fan cooled.
   C. Motors shall be that are variable frequency drive shall be rated for service.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Install power ventilators level and plumb.
   B. Support units using restrained spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment.
   C. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
   D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
   E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch. Vibration-control devices are specified in Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment.
F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Section 23 05 53, Identification for HVAC Piping and Equipment.

H. Duct installation and connection requirements are specified in other Division 23, Heating, Ventilation, and Air Conditioning (HVAC), Sections. Contract Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00, Air Duct Accessories.

I. Install ducts adjacent to power ventilators to allow service and maintenance.

J. Ground equipment according to Section 26 05 26, Grounding and Bonding Electrical Systems.

K. Connect wiring according to Section 26 05 25, Wire and Cable.

3.02 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

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

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3.03 COMMISSIONING

A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain HVAC Power Ventilators systems and equipment. See Section 23 08 00, Commissioning for HVAC for commissioning requirement pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
      a. ASHRAE 70 Method of Testing the Performance of Air Outlets and Air Inlets

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: For each product indicated
C. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
D. Diffuser, Register, and Grille Schedule: Indicate Contract Drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.02 GRILLES AND REGISTERS
A. Adjustable Bar Grille:
   1. Available Products: see schedule
   2. Available Manufacturers:
b. Anemostat; a Mestek Company  
c. Carnes  
d. Dayus Register & Grille  
f. Krueger  
g. METALAIRE, Inc.; Metal Industries Inc.  
h. Nailor Industries of Texas Inc.  
i. Price Industries  
j. Titus  
k. Tuttle & Bailey  

3. Material: Stainless steel  
4. Finish: Baked enamel, color selected by Architect  
5. Face Blade Arrangement: Fixed horizontal spaced 1/2 inch apart  
6. Frame: 1-1/4 inches wide  
7. Mounting: as scheduled  
8. Damper Type: Opposed blade with spring-closing and UL-listed fusible link for 160 degrees F  
9. Accessories: Front-blade gang operator  

B. Fixed Face Grille:  
1. Available Manufacturers:  
   b. Anemostat; a Mestek Company  
   c. Carnes  
   d. Dayus Register & Grille  
   f. Krueger  
   g. Nailor Industries of Texas Inc.  
   h. Price Industries  
   i. Titus  
   j. Tuttle & Bailey  
2. Material: Steel
3. Finish: Baked enamel, color selected by Architect
4. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid core
5. Frame: 1-1/4 inches wide
6. Mounting: scheduled
7. Damper Type: Opposed blade with spring-closing and UL-listed fusible link for 160 degrees F

2.03 CEILING DIFFUSER OUTLETS

A. Round Ceiling Diffuser:
   1. Available Manufacturers:
      a. Anemostat; a Mestek Company
      b. Carnes
      d. METALAIRE, Inc.; Metal Industries Inc.
      e. Nailor Industries of Texas Inc.
      f. Price Industries
      g. Titus
      h. Tuttle & Bailey
   2. Material: Steel
   3. Finish: Baked enamel, color selected by Architect
   4. Face Style: Four cone
   5. Pattern: Fully adjustable
   6. Dampers: Combination damper and grid
   7. Accessories:
      a. Equaling grid
      b. Plaster ring
      c. Safety chain
      d. Wire guard
      e. Sectorizing baffles
      f. Operating rod extension

B. Rectangular and Square Ceiling Diffusers:
1. Available Manufacturers:
   b. Anemostat; a Mestek Company
   c. Carnes
   e. Krueger
   f. METALAIRE, Inc.; Metal Industries Inc.
   g. Nailor Industries of Texas Inc.
   h. Price Industries
   i. Titus
   j. Tuttle & Bailey

2. Material: Steel

3. Finish: Baked enamel, color selected by Architect

4. Face Size: 24 by 24 inches

5. Face Style: Four cone

6. Mounting: As schedule

7. Pattern: Adjustable

8. Dampers: Radial opposed blade

9. Accessories:
   a. Equaling grid
   b. Plaster ring
   c. Safety chain
   d. Wire guard
   e. Sectorizing baffles
   f. Operating rod extension

2.04 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Contract Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Resident Engineer for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.02 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 23 41 00

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 SUMMARY
   A. This Section includes specifications for factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.02 REFERENCES
   A. This Section incorporates by reference the latest revisions of the following documents.
      1. National Fire Protection Association (NFPA)
         a. NFPA 70 National Electric Code
         b. NFPA 90A Installation of Air Conditioning and Ventilating Systems
         c. NFPA 90B Installation of Warm Air Heating and Air-Conditioning Systems
      2. The Air-Conditioning and Refrigeration Institute (ARI)
         a. ARI 850 Commercial and Industrial Air Filter Equipment
      3. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
         a. ASHRAE 52.1 Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
         b. ASHRAE 52.2 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

1.03 SUBMITTALS
   A. Procedures: Section 01 33 00, Submittal Procedures.
   B. Product Data: Include dimensions; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each unit indicated.
   C. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.
      1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
      2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
D. Operation and maintenance data.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ARI 850.

C. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

D. Comply with NFPA 90A and NFPA 90B.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. AAF International
2. Air Filter International
3. Airguard Industries, Inc.
4. Barnebey & Sutcliffe Corp.
5. Columbus Industries, Inc.
6. CRS Industries, Inc.; CosaTron Div.
7. D Mark Inc.
8. Farr Co.
10. Flanders/CSC Corp.
11. Flanders Filters, Inc.
12. General Filters Inc.
13. International Air Filtration Corporation
14. Koch Filter Corporation
15. LakeAir International, Inc.
17. Purafil, Inc.
18. Research Products Corp.
B. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with holding frames.
   1. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
   2. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
   3. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

C. Extended-Surface, Disposable Panel Filters: Factory-fabricated, dry, extended-surface filters with holding frames.
   1. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
   3. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, and suitable for bolting together into built-up filter banks.

D. Side-Service Housings: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct system.
   1. Integral Tracks: Accommodate 2-inch disposable or washable filters.
   2. Access Doors: Continuous gaskets on perimeter and positive-locking devices. Arrange so filter cartridges can be loaded from either access door.
   3. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Coordinate filter installations with duct and air-handling unit installations.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for variable-volume, modular air-handling units with coils for indoor installations.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 23 05 00, Common Work Results for HVAC
2. Section 23 05 13, Common Motors Requirements for HVAC Equipment.
3. Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment.
4. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC
5. Section 23 08 00, Commissioning for HVAC
6. Section 23 09 00, Instrumentation and Control for HVAC.
7. Section 25 60 00, Building Management System
8. Section 26 05 26, Grounding and Bonding for Electrical Systems.
9. Section 26 29 13, Enclosed Controllers

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American Society for Testing and Materials International (ASTM)
   a. ASTM C 1071 Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Matter)
   b. ASTM C 411 Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
   c. ASTM C 916 Adhesives for Duct Thermal Insulation

2. National Fire Protection Association (NFPA)
   a. NFPA 70 National Electric Code
   b. NFPA 90A Installation of Air Conditioning and Ventilating Systems
c. NFPA 90B Installation of Warm Air Heating and Air-Conditioning Systems

3. Underwriters Laboratory (UL)
   a. UL 1995 Heating and Cooling Equipment
   b. UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
   c. UL 486B Wire Connectors for Use with Aluminum Conductors

4. The Air-Conditioning and Refrigeration Institute (ARI)
   a. ARI 430 Central Station Air Handling Units

5. American Bearing Manufacturers Association (ABMA)
   a. ABMA 9 Load Ratings and Fatigue Life for Ball Bearings
   b. ABMA 11 Load Ratings and Fatigue Life for Roller Bearings

6. Air Movement and Control Association (AMCA)
   a. AMCA 99-2408 Operating Limits for Centrifugal Fans
   b. AMCA 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   c. AMCA 300 Reverberant Room Method for Sound Testing of Fans
   d. AMCA 210 Laboratory Methods of Testing Fans for Rating
   e. AMCA 500 Test Methods for Louvers, Dampers and Shutters

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: For each type of modular indoor air-handling unit indicated. Include the following:

   C. Certified fan-performance curves with system operating conditions indicated.
      1. Certified fan-sound power ratings.
      2. Certified coil-performance ratings with system operating conditions indicated.
      3. Motor ratings, electrical characteristics, and motor and fan accessories.
      4. Material gages and finishes.
      5. Filters with performance characteristics.
      6. Dampers, including housings, linkages, and operators.

D. Shop Drawings: Signed and sealed by a qualified professional engineer.
E. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

2. Wiring Diagrams: Power, signal, and control wiring.

F. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural, mechanical elements, manufacturer’s maintenance clearances, and access requirements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements. Coordination shall include construction sequencing because the units are larger than will fit through the final building passage ways. If the unit is to be assembled on site coordination of sections must be coordinated with the building limitations.

G. Manufacturer Seismic Qualification Certification: Submit certification that modular indoor air-handling units, accessories, and components will withstand seismic forces defined in Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment. Include the following:

H. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

I. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

1. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

J. Field Quality-Control Test Reports: From manufacturer.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by an Independent Testing Laboratory acceptable to authorities having jurisdiction, and marked for intended use.

D. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

E. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
F. Comply with NFPA 70.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03, Concrete.

B. Coordinate size and location of structural-steel support members.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Filters: One set for each modular indoor air-handling unit.
   1. Fan Belts: One set for each modular indoor air-handling unit fan.
   2. Gaskets: One set for each access door.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Airtherm Manufacturing Company.
   1. Buffalo Air Handling.
   2. Carrier; Div. of United Technologies Corp.
   3. CES Group Inc.; Governair, Mammoth, Temtrol, Venmar Ventrol, Webco Divisions.
   4. Dunham-Bush, Inc.
   5. Engineered Air.
   7. Trane Company (The); Worldwide Applied Systems Group.

2.02 MANUFACTURED UNITS

A. Modular indoor air-handling units shall be factory assembled complete or in sections and consist of fans, motor and drive assembly, coils, damper, plenums, filters, dampers, control devices, and accessories. Unit shall be provided with single point electrical connection for all associated electrical devices. Devices include but are not limited to motors, starter, variable frequency drive, actuators, control transformers, etc.

B. Field assembled sections shall be provided with permanent, factory-applied bulb-type gaskets.

C. Air handling unit fans housings shall fit through a standard 36-inch door.
2.03 CABINET

A. Materials: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Outside Casing: Galvanized steel, 0.0635 inch thick.
   1. Inside Casing: Galvanized steel, 0.0276 inch thick.
   2. Floor Plate: Galvanized steel, 0.1382 inch thick.

C. Cabinet Insulation: Comply with NFPA 90A or NFPA 90B.

D. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.
   1. Thickness: 2 inches.
   2. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
   4. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.
   5. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   6. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from and including the cooling coil section.

E. Access Panels and Doors: Same materials and finishes as cabinet, complete with hinges, latches, handles, and gaskets. Inspection and access panels and doors shall be sized and located to allow periodic maintenance and inspections. Provide access panels and doors in the following locations:
   1. Fan Section: Doors.
   2. Access Section: Doors.
   3. Coil Section: Doors (unless fully and directly accessible from other doors).
   4. Damper Section: Doors.
   5. Filter Section: Doors to allow periodic removal and installation of filters.

2.04 FAN SECTION

A. Fan-Section Construction: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan with vibration isolation.
B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.

C. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   1. Performance Class: AMCA 99-2408, Class I, I, or III according to scheduled static pressure.
   2. Horizontal Flanged Split Housing: Bolted construction.

D. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.

E. Fan type shall be as scheduled:
   1. Forward-Curved Fan Wheels: Black-enamel or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
   2. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange, heavy backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

F. Coatings: Powder-baked enamel.

G. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

H. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
   1. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

I. Bearings shall be as appropriate for the fan selected.
   1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 120,000 hours.
   3. Roller-Bearing Rating Life: ABMA 11, L_{10} of 120,000 hours.

J. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor.

K. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
1. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

2. Belts: Oil resistant, nonsparking, and nonstatic; matched for multiple belt drives.

3. Belt Guards: Fabricate to OSHA/SMACNA requirements; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen welded to steel angle frame or equivalent; prime coated.


L. Vibration Control: Install fans on open-spring vibration isolators having a minimum of 1-inch static deflection and side snubbers.

M. Fan-Section Source Quality Control:


   a. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

2.05 MOTORS

A. General: Comply with requirements in Section 23 05 13, Common Motors Requirements for HVAC Equipment.

B. Motors that are Variable Frequency Drive shall be rated as such.

C. Noise Rating: Quiet.

2.06 VARIABLE FREQUENCY CONTROLLER AND STARTERS

A. Provide Starters: As specified in Section 26 29 13, Enclosed Controllers.

B. Provided Variable Frequency Drives: As specified in Section 26 29 13, Enclosed Controllers.

2.07 COILS

A. Coil Sections: Common or individual, insulated, galvanized-steel casings for heating coils. Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils.


C. Casing Assembly: Flanged type with galvanized-steel frame.

1. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
2. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.
   a. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

D. Control Panel: Remote mounted with disconnecting means and overcurrent protection. Include the following controls:
   a. Magnetic contactor.
   b. Mercury contactor.
   c. Solid-state stepless pulse controller.
   d. Toggle switches, one per step.
   e. Time-delay relay.
   f. Pilot lights, one per step.
   g. Airflow proving switch.
   h. 15HP motors or larger shall be equipped with soft start controller run command from BMS.

2.08 DAMPERS
A. Refer to the drawings for arrangement of outside air and bypass dampers. Size by pass dampers for parallel mounting with electric heating coil
B. General: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.
C. Damper Actuators: Electric specified in Section 23 09 00, Instrumentation and Control for HVAC.
D. Low-Leakage, Outside-Air Dampers, Exhaust Dampers,: Double-skin, airfoil-blade galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in parallel-blade arrangement with steel operating rods rotating in stainless-steel sleeve bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.
E. Mixing Boxes: Parallel-blade galvanized-steel dampers mechanically fastened to steel operating rod in reinforced, galvanized-steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

2.09 CONTROLS
A. Provide control terminals arranged as shown on Building Management System plans.

2.10 FILTER SECTION
A. Filters: Comply with NFPA 90A.
B. Filter Section: Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side.

C. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with holding frames.

D. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
   1. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
   2. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

E. Extended-Surface, Disposable Panel Filters: Factory-fabricated, dry, extended-surface filters with holding frames.

F. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
   1. Media and Media-Grid Frame: Galvanized steel.


H. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated airflow conditions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.02 INSTALLATION

A. Concrete Bases: Install floor mounting units on 4-inch high concrete bases. See Section 23 05 00, Common Work Results for HVAC, for concrete base materials and fabrication requirements.

B. Install modular indoor air-handling units with the following vibration and seismic-control devices. Vibration and seismic-control devices are specified in Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment.

C. Units with Internally Isolated Fans: Secure units to anchor bolts installed in concrete bases.

D. Arrange installation of units to provide access space around modular indoor air-handling units for service and maintenance.
3.03 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

B. Electrical: Comply with applicable requirements in Division 26, Electrical, Sections for power wiring, switches, and motor controls.

C. Ground equipment according to Section 26 05 26, Grounding and Bonding for Electrical Systems.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 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. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.05 STARTUP SERVICE

A. See Section 23 08 00, Commissioning of HVAC for additional requirements.

B. Engage a factory-authorized service representative to perform startup service.

C. Final Checks before Startup: Perform the following:

   1. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

   2. Perform cleaning and adjusting specified herein.

   3. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

   4. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

   5. Set outside air dampers to match flow setting.


   7. Install clean filters.
Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

E. Starting procedures for modular indoor air-handling units include the following:

F. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
   1. Measure and record motor electrical values for voltage and amperage.
   2. Manually operate dampers from fully closed to fully open position and record fan performance.

G. Refer to Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for modular indoor air-handling system testing, adjusting, and balancing.

3.06 ADJUSTING
   A. Adjust damper linkages for proper damper operation.

3.07 CLEANING
   A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer’s written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
   B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

3.08 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Sound Transit’s maintenance personnel to adjust, operate, and maintain modular indoor air-handling units.

3.09 COMMISSIONING
   A. Engage a factory-authorized service representative to train Sound Transit's maintenance personnel to adjust, operate, and maintain Modular Indoor Central Station Air Handling Units systems and equipment See Section 23 08 00, Commissioning for HVAC for commissioning requirement pertaining to the work of this Section.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Section defines requirements for the design, installation, testing and commissioning of the Building Management System (BMS). The BMS is a programmable logic controller (PLC) based monitoring and control system for equipment in the light rail station. Facilities monitored/controlled by the BMS include mechanical, fire, electrical, lighting, vertical transportation, irrigation and access control. Emergency fans and dampers are monitored and controlled by the Emergency Ventilation System (EVS) not by the BMS.

B. Related Sections

1. Section 01 33 00, Submittals
2. Section 22 05 50, Mechanical Identification.
3. Section 26 05 25, Wire and Cables
4. Section 26 05 33, Raceways, Boxes, and Cabinets
5. Section 27 13 00, Optical Fiber Cabling

1.02 REFERENCES

A. Abbreviations and Acronyms

1. AC Alternating Current
2. ASCII American Standard Code for Information Interchange
3. BMS Building Management System
4. DC Direct Current
5. EFN Emergency Fan Network
6. EVS Emergency Ventilation System
7. HMI Human Machine Interface
8. HVAC Heating Ventilation and Air Conditioning
9. ID Identification
10. I/O Input/Output
11. IP Internet Protocol
12. ITC  Interface Terminal Cabinet
13. KVM  Keyboard, Video, Mouse
14. O&M  Operation & Maintenance
15. PAC  Programmable Automation Controller
16. PDF  Portable Document Format
17. PLC  Programmable Logic Controller
18. SCADA  Supervisory Control and Data Acquisition
19. TCN  Train Control Network
20. VLAN  Virtual Local Area Network

B. Definitions

1. Comm: An abbreviation for Communications Systems, the collection of networks, phone systems, radio, public address, variable message signs, cameras, access control and the HMI computers for interacting with these subsystems.

2. Controller or Field Controller: A generic term for the processor module in the PLC or building management system.

3. Graphic Interface: Synonymous with HMI. The BMS Graphic Interface is one of several graphic interfaces within Link.

4. Human Machine Interface (HMI): This is a generic term for a computer system providing users with monitoring, control and data processing for interacting with field controllers.

5. Icon: A small picture that represents a functional item in a window. Related terms: Window, Pointer.

6. Input/Output (I/O): The collection of Input and Output information points that a system exchanges with other systems or users.

7. Inputs: Discrete or analog status received by a system from another system or entered by a user.

8. Keyboard-Video-Mouse (KVM): Hardware to control multiple computers from a single keyboard, video monitor and mouse; or to allow a single computer to be controlled from multiple monitors, keyboards, and mice.

9. Logical I/O: I/O in a system that interacts with logic in another system not directly related to physical devices.

10. Menu: Menus appear in Windows and allow the user to execute commands by selecting from a list of choices. Related terms: Window.

11. Monitor:
   a. As a noun, the computer display hardware.
   b. As a verb, the BMS function of receiving and presenting status to a user. Related terms: Display, Screen
12. Outputs: Discrete or analog control points from a system sent to another system or presented to user.


14. Pointer: A graphical image on a screen that indicates the location of a pointing device, and can be used to select and move objects or icons on the screen.

15. Rail Controller: User responsible for monitoring and controlling a process or system using the HMI.

16. Real I/O: I/O in a system directly related to and originating from a physical sensor or control circuit.

17. Settable: Attribute that is able to be configured and modified by the System Administrator.

18. Softcopy: A machine-readable form of corresponding hardcopy (i.e., paper) documents.

19. Supervisory Control and Data Acquisition (SCADA): A generic term for a combined system of an HMI and field controllers providing complete monitoring and control functionality for users. The BMS is one of several SCADA systems.

20. System Administrator: User responsible for adjusting and maintaining the BMS.

21. User: Person interfacing with an HMI (e.g. Rail Controller).

22. Window: A rectangular bordered portion of the screen that displays information independently from the rest of the screen.

23. Workstation: An operating position with one or more monitors presenting an HMI or graphic interface.

C. Reference Standards

1. Federal Transportation Administration (FTA)
   a. DOT-FTA-MA 26-5005-00-01 Hazard Analysis Guidelines for Transit Projects

2. Institute of Electrical and Electronics Engineers (IEEE)
   a. IEEE 610 Standard Glossary of Software Engineering Terminology
   b. IEEE 730 Standard for Software Quality Assurance Plans
   c. IEEE 828 Standard for Software Configuration Management Plans
   d. IEEE 829 Standard for Software and System Test Documentation
   e. IEEE 830 Recommended Practice for Software Requirements Specifications
   f. IEEE 1012 Standard for Software Verification and Validation
g. IEEE 1016 Standard for Information Technology-Systems Design - Software Design Descriptions

h. IEEE 1058 Standard for Software Project Management Plans

i. IEEE 1044 Standard Classification for Software Anomalies

j. IEEE 1063 Standard for Software User Documentation

k. IEEE 1558 Standard for Software Documentation for Rail Equipment and Systems

3. Military Specification (MIL)
   a. MIL-STD 882C System Safety Program Requirements

4. National Fire Protection Association (NFPA)
   a. NFPA 72 National Fire Alarm and Signaling Code

5. Seattle Building Code

6. Underwriters Laboratory
   a. UL 508 Industrial Control Equipment

1.03 SUBMITTALS

A. Refer to Section 01 33 00, Submittals, for submittal requirements and procedures.

B. Refer to Section 01 95 00, Systems Testing and Integration, for Certified Test Reports requirements.[SDB6]

C. BMS project life cycle from design, development, testing, implementation, and transition shall be documented and managed through submittals.

D. Provide softcopy versions of submittals.

1. Provide original PDF from manufacturers and other suppliers including data sheets, user manuals and other product literature. PDF documents produced from scanned hardcopy are acceptable only if manufacturer does not supply a softcopy version.

2. Provide source files of Contractor produced documents readable by the originating programs including Microsoft Office (e.g., Word, Excel, PowerPoint, Publisher), Visio, and AutoCAD files.

3. Provide PDF versions of Contractor produced documents generated by printing to PDF from the originating program. PDF documents produced from scanned hardcopy are unacceptable. Provide a single PDF file for each physical volume submitted. Add PDF bookmarks consistent with the table of contents and physical tabs of the hardcopy version.

4. Provide Microsoft Excel files for lists and tabular data including:
   a. Drawing list.
   b. Bill of materials.
c. Monitored/controlled equipment list.
d. I/O points list.
e. Documentation cross reference and index.

1.04 INTEGRATOR QUALIFICATIONS SUBMITTAL

A. Submit a certified qualification resume of the contractor or systems integrator performing the fabrication, configuration, and programming of the BMS components.

1.05 DESIGN REVIEW SUBMITTALS

A. Preliminary Design Submittal

1. Configuration Management Plan. Provide hardware and software configuration management plan in accordance with Section 01 45 10, Configuration Management.

2. Hardware Block Diagram. Show the functional arrangement of the hardware components of the station-wide BMS including:
   a. BMS cabinets
   b. interface terminal cabinets (ITC)
   c. PLC racks
   d. Graphic Interface Computers
   e. communication connections between components
   f. communication protocols
   g. ID names of components

3. Network Topology Diagram. Show the network components and cabling detailing BMS communication connections including:
   a. names of networks
   b. VLAN assignments
   c. ID names of components
   d. ID names of cables
   e. port speeds
   f. IP addresses
   g. Modbus device addresses

4. BMS Plan Drawings. Show locations of BMS equipment on scaled station plan drawings including:
   a. BMS cabinets
   b. rack mounted BMS hardware
c. Interface Terminal Cabinets

d. Equipment monitored or controlled by BMS

e. ID names of components

5. Monitored/Controlled Equipment List. List of equipment monitored or controlled by the BMS with fields detailing:

a. ID name of equipment
b. Functional description of equipment
c. Facility or station where equipment is located
d. Room or area where equipment is located
e. ID name of ITC, control panel or other location where I/O wiring from equipment is located

6. Use Case Prototype. Develop format for the written structure of use cases to define BMS functionality and interactions. Provide a prototype and sample example that include at least the following fields:

a. Title
b. Goal
c. Primary Actor
d. Trigger
e. Main Success Scenario: Numbered sequential of the interactions between actors to reach the end goal.
f. Extensions: Numbered sequence of interactions for scenarios branching from the main success scenario.

B. Intermediate Design Submittal

1. Include updated preliminary design submittal items.

2. I/O Points List. Provide a comprehensive list of BMS I/O interfaced to the field and to the BMS Graphic Interface. Include the following columns for descriptive fields for each point:

a. Tagname of the point
b. ID name of equipment (from the monitored/controlled equipment list) associated with the I/O point
c. ID name of the controller
d. ID name of the I/O rack where the point is wired
e. I/O module slot and point where the point is wired
f. Memory address of the point in Controller memory.
g. Point Description: Functional description of the point.

h. Point Type:
1) AI (analog input).
2) AO (analog output).
3) DI (discrete input).
4) DO (discrete output).
5) LAI (logical analog input from controller to graphic interface).
6) LAO (logical analog output to controller from graphic interface).
7) LDI (logical discrete input from controller to graphic interface).
8) LDO (logical discrete output to controller from graphic interface).

i. State: For discrete points, a description of the on and off states in the form “On Description/Off Description”. For analog points, enter “NA”.

j. EU: For analog points, the range and units of the scaled point, for example: “0 10 psi”.

k. Alarm: For discrete inputs enter On/Off/None for the active alarm state. For analog points, enter “NA”. (Alarms for analog inputs shall be developed in field controller logic as logical discrete inputs.)

3. Bill of Materials (BOM). Provide a list of hardware components and off-the-shelf software components with fields detailing:
   
   a. Bill of materials item number
   b. Manufacturer
   c. Model
   d. Description
   e. Quantity used
   f. Quantity of spares

4. Product Data Sheets. Provide product data sheets:
   
   a. Referenced to BOM item number
   b. With arrows indicating model numbers and options selected
   c. Include relevant data such as dimensions, capacities, performance and electrical characteristics.

5. Use Cases. Provide written descriptions of BMS functionality using the accepted prototype use case previously submitted. Use cases shall be clearly written with sufficient detail:
   
   a. For programmer(s) to completely code BMS logic
b. To be used as the basis for test procedures

6. Demonstration Graphics Functional Description. Provide a functional description of the BMS demonstration graphic interface. Provide screen shots with annotations to describe:
   a. Launching and closing the graphic interface program
   b. Display navigation
   c. Instructions for reading status points
   d. Instructions for effecting control actions

C. Final Design Submittal
   1. Include updated preliminary design submittal items.
   2. Include updated intermediate design submittal items.
   3. Shop Drawings. Provide drawings for the fabrication of BMS cabinets, BMS rack mounted assemblies and other BMS hardware to be assembled. Include:
      a. Cabinet enclosure hardware details, dimensions and conduit penetrations
      b. Interior panel elevations showing hardware component layout
      c. Front panel elevations showing indicators, touch panels, switches and buttons, and labels.
      d. Equipment rack elevations
      e. BOM item number call outs
      f. Wiring diagrams clearly differentiating between factory-installed and field-installed wiring.
      g. Terminal strip details, numbering and layout
      h. Conductor and cable labeling
      i. Grounding details
      j. I/O module wiring diagrams
   4. PLC Program Listing. Provide a print out of the PLC logic and cross reference listing.

1.06 TEST SUBMITTALS
   A. Factory Test Plan.
   B. Installation Test Plan.
   C. Functional Performance Test Plan
      1. Include test durations, test criteria, and acceptable functionality and performance criteria for each functional test.
2. Define the acceptable system performance standards.

D. Commissioning Test Plan.

1. Detail the implementation of the commissioning process for the BMS system and Interface Terminal Cabinets.

2. Define the responsibilities, accountabilities, and deliverables by each party within the commissioning process.
   a. System and equipment commissioning scope of work list.
   b. Pre-Commissioning Checklist: Procedure and certification to provide individual verification of all installed system components. Verify that submittal information and installed components match. Review complete system installation, cleaning, and initial settings and verify that system is ready for operations.
   c. Pre-Operation Checklist: Procedure and certification to provide verification, by system or equipment, of system setpoints, operating strategies, and required pre-operational component adjustments and testing such as correct fan rotation and damper operation.

1.07 CLOSEOUT SUBMITTALS

A. Training Plan. Develop training objectives and a format for the training plan and agenda after meeting with appropriate Sound Transit facility and maintenance staff to determine needs and areas of emphasis. Include:
   1. Proposed training schedules
   2. Detailed descriptions of all course contents and training materials.
   3. Training objectives and outline of anticipated means of achieving stated objectives.

   1. As-Built Drawings
   2. Manufacturer User Manuals
   3. Manufacturer Installation Manuals
   4. Manufacturer Data Sheets
   6. Test Documentation. Include completed and signed test procedures.

   1. Include lesson plans that structure presentation of O&M Manual in a series of daily lecture sessions.
   2. Presentation time per session: 1 to 2 hours.
3. Include quizzes with instructor answer key with each lecture session
4. Quizzes shall be designed for completion by students within 15 minutes

1.08 QUALITY ASSURANCE / QUALITY CONTROL

A. Installer Qualifications: Engage an experienced Installer specializing in control system installations with minimum five years documented experience, and approved by the system manufacturer.

B. Manufacturer Qualifications: The hardware shall be furnished by a single vendor for each system. The vendor shall have actively been manufacturing programmable controllers of the required capabilities and whose products have operated successfully for a period of at least 8 years. At Engineer’s request, provide a listing of at least five projects of similar magnitude, complexity and facility use type completed within the past 5 years.

C. System Integrator Qualifications: Systems integrator shall have a minimum of 8 years experience related to design, fabrication, programming, installation, start-up, and testing of similar control systems. If more than one systems integrator is employed, provide a certified resume for each one indicating their specific specialty and item of work.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Products will be considered delivered with the acceptance of submittals.

2.02 PLC HARDWARE

A. For PLC processor provide redundant model RX3i by General Electric.

B. For PLC I/O provide model Series 90-30 by General Electric.

C. Processor, power supply, Input/Output (I/O) cards, communication controllers, components of the PLC system shall have interfaces as shown on Contract Drawings.

D. Spare capacity: Minimum 25 percent spare I/O capacity of input and output types used as shown on the Contract Drawings.

E. Processor Memory: Minimum 48kB, maximum 75 percent usage.

F. Ethernet Port: Two 100Mbps ports.

G. Serial Port: Provide one, supports RS232C, RS422A and RS423 signals, configurable through ladder logic program, capable of writing true ASCII to a printer and other peripheral devices.

H. Spare Memory: Minimum 25 percent.

I. I/O cards.

1. Inputs or Outputs per Card: Maximum of 32.

2. Digital I/O Voltage Level: 120 VAC.

3. LED Status Lamp: Indicate any detected card failure. Failure detection shall be monitored and alarmed by the processor.
4. LED Indication: Light when the associated input or output is present.


6. A/D and D/A conversions shall have an accuracy of 0.1 percent of full scale or better.

7. Provide surge protection on PLC power supplies and I/O circuits in accordance with the latest requirements of IEEE C37.90.1.

8. Provide any filtering or protection equipment necessary to protect the PLC systems from static, inductive pickups or electromagnetic radiation.

9. System shall provide a 60dB common mode rejection capability. Provide battery backup to maintain the CMOS memory in the event of a power outage.

10. The processor's front panel shall have LED indicators to provide system operational information such as processor status and which I/O channels are operational.

11. In event of a PLC or equipment failure, an external system annunciation shall be provided.

12. Diagnostic Routines and Capabilities.

13. Continuously monitor its operational status and be capable of printing an alarm message for any detected failure, including but no limited to: CPU failure, I/O card failure, power supply failure, communications failure. LED indications shall be provided to annunciate these conditions.

14. For any alarm condition or failure that is identified within the system, diagnostic support shall be made available to the operator in order to assist in the identifications and repair of the abnormal condition. Illustrated documentation shall be provided. A system layout and user troubleshooting guides (via modems if necessary) with phone numbers and name of contacts shall also be included.

2.03 BMS CABINET ASSEMBLY AND COMPONENTS

A. Mounting Panel: Painted enamel, 16 gage stainless steel.

B. Control Relays.

1. Standard: UL listed, rated for the intended purpose.

2. Enclosure: Dust proof.

3. Four-pole minimum, eight-pole installed maximum, unless noted or indicated otherwise on the Contract Drawings. Provide a complete set of contacts (e.g., a four-pole block shall have contacts furnished).

4. Provided with track mounted socket and mounting tracks.

5. Provided with non-incandescent, mechanical, neon or LED indicators that illuminate or change position to indicate that the coil is energized.

6. Mechanical Life: 30,000,000 operations.

C. Circuit Breakers.
1. Mounting: DIN rail, mounting track must be provided.
2. Continuous duty Ampacity appropriately rated and indicated on the drawings.
3. Interrupting Capacity: Maximum of 200 A, but not exceeding 100 times rated current.
4. Operating Life: Minimum 6,000 cycles at rated current, 4,000 cycles at 200 percent rated current, minimum dielectric strength of 1,500 VAC.

D. DC Power Supplies.
1. Manufacturer: Sola
2. Mounting: DIN rail, mounting track must be provided.
4. Fusing on both the primary and secondary.
5. Provide disconnecting means for servicing and replacement.
6. Output Voltage: Adjustable plus or minus 10 percent.
7. Input Voltage: Single voltage 2 wire, 100 to 240 VAC.
8. Operating Temperature: 14 to 140 degrees F.
9. Rated: Actual load plus 50 percent.

E. Control Power Transformers.
1. Provide factory-assembled, general-purpose, ventilated, dry-type distribution transformers of rated VA capacities required.
2. Rated for continuous operation, at rated VA, without exceeding a total winding temperature, as indicated below.
3. Insulation System Classification.
4. Electrically grounded to enclosure by means of a flexible metal grounding strap.
5. An electrostatic shield shall be placed between the primary and secondary windings.
6. Include fusing on both the primary and secondary.
7. Provide disconnecting means for servicing and replacement.

F. Terminal Blocks.
1. Manufacturer: Wago
2. Incoming and outgoing wiring to the panel shall be landed on DIN rail mounted, finger safe terminal blocks.
3. Discrete I/O wiring terminal blocks shall accept between #28 to #12 AWG wires. Select different colors to distinguish inputs and outputs.
4. Analog inputs circuits shall be landed on fused terminal blocks with indicating lamp for blown fuse. Include appropriate fuses rated to protect PLC inputs.

5. Terminal blocks shall accept the wires using a spring clamping mechanism. Screw-type terminal blocks shall not be accepted.

G. Wire and Cable.

1. Power and 120 VAC Control Wiring: Single conductor, stranded, soft annealed copper conductors with 600 V insulation type XHHW. Wire smaller than No. 14 gauge shall not be used unless specifically called for on drawings.

2. 24 V wiring: Shielded twisted pair, 600 V, 90 degrees C.

3. Conductors: 18 AWG, stranded copper rated for 300 VAC service.

4. Conductor insulation: 15 mils PVC and 5 mils nylon.

5. Foil shield with tinned copper drain wire.

6. Jacket: 50 mil Black PVC.

7. Signal wiring for analog inputs: 18 AWG single or multiple twisted pair and 18 AWG drain wire. Insulation shall be rated for 300 VAC.


H. Panel Holes.

1. Panel Holes: Drilled and tapped for long-term flexibility and ease of equipment replacement and/or upgrade.

2. Hole and/or Penetration Point: Touched-up with proper sealant to minimize corrosion prior to mounting components.

I. Labels and Nameplates: Nameplates shall be both glued and screwed in place for longevity. Identify wires at both ends with permanent labels.

J. Wiring Duct.

1. Wiring Duct: Used to enclose panel wiring as required to provide the appearance of good workmanship.

2. Color: Same throughout the panel.

3. Securely fasten to panel with screws and washers or rivets.

4. Fill: Maximum 75 percent.

5. Route wiring within digital and ancillary control panels by duct wherever possible. Wire shall be neatly and symmetrically arranged within the control cabinet.

6. Provide from entry point of external cable to the termination point of the cables. Form AC and DC wiring leading from the devices and terminal blocks to the field to exit separately in dedicated areas on the top and/or bottom of the panel.

7. Weld studs for supporting cable bundles at key stress points without use of adhesive style mounting devices.
8. Comb and neatly align wires to prevent unnecessary stress in wire bundle.

9. When terminating twisted shielded cables, insulate PVC with heat shrink and sleeve ground conductor safety.

K. Terminal Block Wiring.

1. Terminate wiring entering and leaving control panels on a numbered terminal strip.

2. Arrange wiring for vertical conduit entry. Terminal blocks shall have no more than two wires connected per termination point. Factory jumpers may be used where required.

3. Number terminals with a permanent, nonconductive strip on each block according to detailed wiring drawings. Provide mounting track to anchor terminal blocks to control panel.

4. Terminal Strip Colors (not wire colors):
   c. Analog Input Points: Purple.
   d. Analog Output Points: Yellow.
   g. Power Supply (internal 24 VAC or VDC): Blue (hot), Gray (neutral).
   h. Power Supply (external 24 VAC or VDC): White (hot), Gray (neutral).
   i. Power Supply (120 VAC or less): Black (hot), Gray (neutral).
   j. Any voltage greater than 120 VAC: Orange (hot), Gray (neutral).
   l. Grounds: Green.
   m. Other Terminal Connections: Beige.

L. Grounding: Connect ground wire terminal of each device to grounding conductor. Material and installation shall comply with National Electrical Contractors Association’s "Standard of Installation” pertaining to the installation, grounding and bonding of circuits and equipment.

M. DC Power Supply

1. Combined voltage regulation, noise suppression type transformer shall be rated 3000 VA, minimum at 120 V, single phase output with line voltage fluctuation 25 percent below nominal, as manufactured by Sola, MCR Series Power conditioner or approved equal.

N. I/O Network Ethernet Switches
1. Number of Fiber optic ports:
   a. Switch at Controller: number of I/O racks + 25%
   b. Switches at BMS I/O: 2

2. Number of RJ45 ports: 4

3. Ethernet Speed: 10/100 MBs

2.04 PROGRAMMING LAPTOP

A. Provide one maintenance laptop loaded with required application software to support system administration, testing, and maintenance.

B. Each laptop computer shall be Dell Precision M6500 or approved equal, with the following minimum requirements:
   1. IBM compatible External optical mouse
   2. Built-in Wi-Fi
   3. 17" display, 1920x1200 resolution, color active matrix type display
   4. Padded leather carrying case

C. Each laptop computer shall be equipped with the following software:
   1. Microsoft Windows operating system, latest version in use by Sound Transit with latest service pack version.
   2. Microsoft Office, latest version in use by Sound Transit
   3. Antivirus
   4. DVD+RW and CD-RW editing software, latest version in use by Sound Transit, Acrobat Professional, latest version in use by Sound Transit Application software to support system administration, testing, and maintenance activities.

2.05 BMS DEMONSTRATION GRAPHICS

A. The final BMS Graphic Interface will be provided by others. Provide a demonstration BMS Graphic Interface sufficient for testing and commissioning. The demonstration graphics shall:
   1. Organize I/O points in tables showing address, tagname, description, and state (on/off or analog value)
   2. Provide tables of I/O organized by PLC I/O module
   3. Provide tables of I/O organized by equipment or system
   4. Interface to the BMS controller graphic interface I/O points via the same network channel and using the same communication protocols as indicated on the Drawings for the permanent graphics.
   5. Interface to BMS real I/O points to show status of inputs and outputs.
   6. Include control mechanisms to turn discrete points on or off.
7. Include control mechanisms to write data to analog registers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment as indicated to comply with manufacturer's written instructions.

B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve approved Use Cases.

D. Install labels and nameplates to identify control components according to Section 22 05 50, Mechanical Identification.

3.02 ELECTRICAL WIRING AND CONNECTIONS

A. Install raceways, boxes, and cabinets according to Section 26 05 33, Raceways, Boxes, and Cabinets.

B. Install building wire and cable according to Section 26 05 25, Wire and Cables.

C. Install signal and communication cable according to Section 26 05 25, Wire and Cable.

D. Install all cables and conductors in raceway.

E. Conceal raceway, except in mechanical rooms and areas where other conduit and piping are exposed.

F. Bundle and harness multi-conductor instrument cable in place of single cables where a number of cables follow a common path.

G. Fasten flexible conductors, bridging cabinets and doors, neatly along hinge side; protect against abrasion. Tie and support conductors neatly.

H. Label all control conductors, utilizing identifying labels shown on the Plans, for future identification and servicing of control system.

I. Connect electrical components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

3.03 FIELD QUALITY CONTROL

A. BMS Signal Integrity: Checks shall be performed as part of the Pre-Commissioning Checklist to verify interconnections between the BMS system and the field instruments and devices. All signal interconnections shall be individually physically verified for proper terminations and noted on the Pre-Commissioning Checklist. Completed checklist shall be submitted as part of the final test report.

B. Interface Terminal Cabinets: Checks shall be performed as part of the Pre-Commissioning Checklist to verify correct interconnections between the Link Control Interface Terminal Cabinet terminals and the field equipment, instruments and devices.
All signal interconnections shall be individually physically verified for proper terminations and noted on the Pre-Commissioning Checklist. Completed checklist shall be submitted as part of the final test report.

3.04 COMMISSIONING

A. Manufacturer's Field Services: Provide the services of a factory-authorized service representative to assist in commissioning of DDC systems.

B. Contractor to replace, at no cost to Sound Transit, all controls and equipment found to be damaged, malfunctioning, or that does not meet acceptable system performance standards. Submit a corrective action plan for all noted deficiencies identified during the commissioning process.

3.05 TRAINING

A. Provide training for a minimum of eight Sound Transit Employees as follows:

1. Lecture sessions and quizzes per approved Training Plan.

2. Train BMS functional operation and monitoring of each ventilation, HVAC, plumbing, and electrical system within the station. Training to include complete overview of system operation and available operating modes and parameters.

3. Maintenance training covering each aspect of preventative maintenance, emergency repair, and control unit modification.

3.06 SPARE PARTS

A. All spare parts shall conform to the requirements of Part 2, Products, of this section.

B. Provide the indicated quantity and type of new spares, in original unopened packaging, to enable the replacement of the following components in the event of a failure: Six (6) of each type of fuse used within the BMS system.

C. Two (2) of each type and rating of relays and contactors used.

D. Three (3) of each type of relay/contactor/module socket base used.

E. Two (2) of each type and rating of channel mounted circuit breakers used.

F. Two (2) of each type of processor, I/O, communications and power supply module used.

END OF SECTION
SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for wiring devices, disconnect switches, fuses, and control relays.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. IEEE C2 National Electrical Safety Code (also an ANSI Standard)

2. International Conference of Building Officials:
   a. International Building Code (IBC)

3. National Electrical Contractors Association (NECA):
   a. NECA 1 Standard Practices for Good Workmanship in Electrical Construction

4. National Electrical Manufacturers Association (NEMA):
   a. NEMA KS 1 Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
   b. NEMA WD 1 General Requirements for Wiring Devices
   c. NEMA WD 5 Specific-Purpose Wiring Devices
   d. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

5. National Fire Protection Association (NFPA):
   a. NFPA 70 National Electrical Code
   b. NFPA 130 Fixed Guideway Transit and Passenger Rail Systems

6. Underwriter's Laboratories (UL):
   a. UL 198E Class R Fuses

   a. 19.27 RCW Washington State Building Code
   b. 19.28 RCW Electricians and Electrical Installations
   b. 296-46 WAC Safety Standards – Installing Electric Wires and Equipment – Administrative Rules

1.03 SUBMITTALS

A. Procedure: Section 01 33 00, Submittal Procedures.

B. List of Materials: At least 30 days before beginning the work of this Section, submit a list of materials and equipment proposed for use. Give name of manufacturer, brand name, and catalog number of each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by Specifications Section and Article numbers.

C. Compliance with Applicable Standards:
   1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASTM, IEEE, and NEMA, submit evidence of such conformance for review and record purposes.
   2. The label or listing of the specified agency will be acceptable evidence.
   3. Instead of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified standard.

D. Factory Test and Inspection Certification:
   1. Where factory tests and inspections for materials and equipment specified in referenced documents are waived, provide certified copies of reports for tests performed on previously manufactured identical materials or equipment within the previous 12 months.
   2. Accompany test reports by signed statements from the manufacturer certifying that the previously tested material or equipment is physically, mechanically, and electrically identical to that proposed for the Contract. Include wiring and control diagrams.

E. Shop Drawings: Submit shop drawings showing equipment layouts and fabricated work being provided under these Specifications. Submit such drawings before rough-in work, fabrication, and within ample time to prevent delays in the Work. Include electrical diagrams for equipment and equipment installation.

F. Field Test Reports: Submit certified field test reports of field tests, verifying compliance of equipment and systems with Specification requirements.
G. Operation and Maintenance Manuals: Submit operation and maintenance instructions and data for equipment provided under this Division, in accordance with the requirements of Section 01 78 23, Operation and Maintenance Data. Include recommended maintenance materials and spare parts list for installed equipment.

1.04 QUALITY ASSURANCE

A. Qualifications: Ensure workers performing work meet the qualification and licensing requirements of Chapter 19.28 RCW (Electricians and Electrical Installations).

B. Perform work in compliance with the following industry standards and regulations.

1. NFPA 70 National Electrical Code.
2. NECA 1, Standard Practices for Good Workmanship in Electrical Construction.
4. State of Washington Business Regulations and Administrative Codes:
   a. Chapter 19.27 RCW
   b. Chapter 19.28 RCW
   c. Chapter 51-40 WAC
   d. Chapter 296-46 WAC
5. Relevant amendments to Washington State regulations and codes adopted by local jurisdictions.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Furnish materials and equipment of design, sizes, and ratings as indicated- suitable for the intended purpose and per the requirements below.

1. At all new garages, platforms and stations: Use NEMA rated cast boxes.

B. Furnish materials and equipment acceptable to the authority having jurisdiction bearing label or classification listing of a nationally-recognized testing laboratory where product labeling or listing is available.

C. Methods of fabrication, assembly, and installation are optional unless otherwise indicated.

D. Provide products that are free from defects, which may impair performance, durability, or appearance.

E. For tunnel installation, use materials including exposed raceways, boxes, cabinets, luminaires, equipment enclosures, and their surface finish material which are capable of being subjected to temperatures up to 932 degrees F for 1 hour and do not support combustion as required by NFPA 130.
2.02 COMPONENTS

A. SWITCHES

1. Provide ac, tumbler-type toggle switches conforming to minimum requirements of NEMA WD 1, heavy-duty general use type.

2. Provide switches that operate in any position and are fully enclosed with entire body and cover of molded phenolic, urea, or melamine. Do not use fiber, paper, or similar insulating material for body or cover.

3. Equip switches with metal mounting yoke with plaster ears, insulated from the mechanism and fastened to the switch body by bolts, screws, rivets, or other substantial means.

4. Provide the section of the yoke normally intended to bear on the surface outside the box with a minimum over-all dimension of 3/4 inch, measured at right angles to the longitudinal axis of the yoke.

5. Use switch contacts of silver or silver alloy.

6. Use switches that are back or side wired with terminals of screw or combination screw-clamp type.

7. Use terminal screws No. 8 or larger, captive or terminal type.

8. For switches to be used on incandescent or fluorescent lighting circuits use fully-rated 20 A at 120 V or 277 V.

9. Switches controlling straight resistance loads may be snap switches as specified herein, of the proper rating up to 30 A at 120 - 277 V.

10. Provide 120 - 277 V ac snap switches capable of withstanding tests as outlined in NEMA WD 1. If requested by the Resident Engineer, submit evidence that the types of switches proposed have satisfactorily withstood these tests.

B. RECEPTACLES

1. Receptacle Standards: Ensure connector and outlet receptacles conform to NEMA WD 1, heavy-duty general use type.

2. Convenience Receptacles:
   a. Provide receptacles with fire-resistant, nonabsorptive, hot-molded phenolic composition bodies and bases and with metal plaster ears integral with supporting member.
   b. Use receptacles that are 20R configuration, single- or duplex-type as indicated. Use receptacles that are back- and side-wired with screw or combination screw-clamp terminals.
   c. For contacts of the receptacles, including the grounding contact, use double-grip bronze type with spring steel backup clips so that both sides of each male prong of the plug will be in firm contact.

4. **GFCI Receptacles:** For ground fault circuit interrupter (GFCI) duplex receptacles use 120 V, 60 Hz, 20 A with built-in test, reset buttons, and ground fault tripped indication. Ensure they interrupt the circuit within 1/30 second on a 5 milliampere earth leakage current. Use GFCIs designed for end of run installation or with provisions for feeding through to protect other outlets on the circuit. Circuit capacity for the latter is 20 A. Furnish receptacles with necessary wire connectors, clips, mounting screws, and instructions.

C. **COVER PLATES**

1. Provide multi-gang plates where required. Segmented cover plates are not acceptable.

2. Finished area device covers: brushed, stainless steel, 0.040-inch thickness.


4. For special purpose outlets, provide plates of brushed stainless steel and of a design for the particular application.

5. Weatherproof cover plates: die-cast, copper-free aluminum listed for wet locations with self-closing spring door and rubber gasket. Provide rain cover where required or as indicated.

6. Public Area outlet boxes and covers shall be duplex receptacle, hinged locking cover, stainless steel outlet boxes. The outlet boxes and covers shall be rated for a harsh environment and be made of Type 302 stainless steel with a gasketed cover. The lock cylinder will be furnished under Section 08 71 00.

D. **INDIVIDUAL CONTROL RELAYS**

1. Use control relays which have convertible contacts rated a minimum of 10 A, 600 V. Verify coil voltage, and number and type of contacts. Provide NEMA 250 Type 1 enclosures.

**PART 3 - EXECUTION**

3.01 **INSTALLATION**

A. Install products in accordance with product listings, manufacturer’s recommendations, relevant codes and regulations, and standard industry practice for electrical installations.

B. Install electrical materials, equipment, appurtenances, and accessories in locations as indicated, in accordance with NECA 1, to provide a complete and operable system. Do not weld electrical materials for attachment or support.

C. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

D. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the work rigidly.

E. Conform to the seismic restraint requirements of the International Building Code and Washington State Building Code. Ensure electrical equipment installed under these
Specifications conforms to IBC Section 1621, Architectural, Mechanical, and Electrical Component Seismic Design Requirements.

F. Control erection tolerance requirements so as to not impair the strength, safety, serviceability, or appearance of the installations.

G. Install switches, receptacles, special purpose outlets, and cover plates complete in accordance with NECA 1, the National Electrical Code, and local electrical codes.

H. Seal equipment enclosures against dust, whenever dusty conditions are present inside the rooms or outside, during the construction period.

3.02 CONSTRUCTION

A. WIRING

1. Provide wiring systems complete as indicated and required for proper service. Provide ample slack wire for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

B. WIRING DEVICES AND COVER PLATES

1. Locate wiring devices at heights in accordance with NECA 1, except as otherwise indicated.

2. For exterior and damp locations including passenger stations, mount receptacles in watertight cast metal outlet boxes with threaded hubs or bosses and provide with weatherproof cover plate.

3. Provide water-tight, locking-type male plugs protected by a ground-fault circuit interrupter for equipment subject to spray or hose cleaning.

4. Provide GFCI duplex receptacles in public areas and trainways.

5. Provide cover plates for each switch, receptacle, and special purpose outlet.

6. Provide brushed stainless steel cover plates in finished areas.

7. Provide galvanized steel cover plates in ancillary spaces, mechanical rooms, fan rooms, electrical closets, electrical rooms, traction power substations, and unfinished areas.

C. INTERFACE WITH OTHER WORK

1. Coordinate the work of this Section with the other Sections of this Division 26, Electrical, as required to provide a complete and operable electrical installation.

2. Coordinate electrical services and work with the serving utility company and the Resident Engineer, as applicable.

3. Coordinate with work completed or in progress or to be performed under other sections of these Specifications or by other contractors. Make indicated connections to previously completed work. Where future connections to or extensions of the work are indicated, provide safe and convenient provisions for such future connections and extensions.
4. Contract Drawings show electrical equipment, ductbanks, raceways, and other electrical facilities diagrammatically and do not show all accessories or fittings that may be required because of obstructing structural features and architectural finishes, interfering utilities, ducts, and mechanical equipment. Investigate such conditions and determine the need for locating equipment and materials and routing electrical raceways clear of such obstructions and interferences. Provide complete and operable electrical systems and installations in conformance with these Specifications.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 26 05 17
DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing and installing dry-type transformers.

1.02 REFERENCES
A. This Section incorporates by reference the latest revision of the following documents.
   1. National Electrical Manufacturers Association (NEMA):
      a. NEMA ST 20 Dry Type Transformers for General Applications
      b. NEMA TP 1 Guide for Determining Energy Efficiency for Distribution Transformers

1.03 SUBMITTALS
A. Procedure: Section 01 33 00, Submittal Procedures.
B. Product Data: Submit manufacturer's product data of manufactured materials and equipment including the following.
   1. Outline and support point dimensions of enclosures and accessories
   2. Unit weights
   3. Voltage, kVA and impedance ratings and characteristics
   4. Loss data, efficiency at 25, 50, 75 and 100 percent rated load
   5. Sound level
   6. Tap configuration
   7. Insulation system type and rated temperature rise.
C. Operation and Maintenance Data: Submit in accordance with Section 01 78 23, Operation and Maintenance Data, including the requirements identified above for submittal information.
D. Test Reports: Submit test reports of factory and field tests performed, verifying that performance of equipment meets specification requirements.

1.04 DELIVERY, STORAGE AND HANDLING
A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage or distortion.
B. Store transformers in secure, warm and dry storage facility.
C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.01 MATERIALS

A. DRY TYPE TWO-WINDING TRANSFORMERS

1. Dry Type Transformers: NEMA ST 20 and TP 1; factory-assembled, copper windings, k=4, air cooled dry type transformers; ratings as shown on Contract Drawings.

2. Insulation system and average winding temperature rise for rated kVA as follows:
   a. 1 to 15 kVA: Class 220 insulation, 115 degrees C rise.
   b. 16 to 500 kVA: Class 220 insulation, 115 degrees C rise.
   c. 501 to 2000 kVA: Class 220 insulation, 80 degrees C rise.

3. Load Ratings and Transformer Cooling: Load ratings, unless noted otherwise, are assumed to be AA (air convection cooling). For transformers larger than 500 kVA, provide mounting hardware and internal thermostats appropriate for future installation of external fans. Provisions shall be capable of increasing the transformer full-load rating by 50 percent.

4. Winding Taps
   a. Transformers Less than 15 kVA: Two 5 percent, full-capacity taps below rated voltage on primary winding.
   b. Transformers 15 kVA and larger: NEMA ST 20.

5. Sound Levels: NEMA ST 20

6. Basic Impulse Level.
   a. Low-voltage Dry-Type Transformers: 10 kV.

7. Ground core and coil assembly to enclosure by means of a visible, flexible copper grounding strap.

8. Mounting: Transformers 75 kVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 kVA shall be suitable for floor or trapeze mounting.

9. Coil Conductors: Continuous windings with terminations brazed or welded.

10. Enclosure: NEMA ST 20; Type 1, drip-proof.

11. Isolate core and coil from enclosure using vibration-absorbing mounts.

12. Nameplate: Include transformer connection data.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Set transformers plumb and level.

B. Use flexible conduit, 2-foot minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the structure.

D. Provide restraints for vertical and horizontal seismic motion in accordance with the seismic requirements in Section 26 05 00, Common Work Results for Electrical.

3.02 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION
SECTION 26 05 25
WIRE AND CABLE

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing and installing low voltage wires and cables, wiring connections, and terminations.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. 26 08 00, Commissioning of Electrical Systems

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents

1. American Railway Engineering and Maintenance-of-Way Association (AREMA):
   a. AREMA Signal Manual

   a. ASTM B 3 Specification for Soft or Annealed Copper Wire
   b. ASTM D 1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
   c. ASTM D 1518 Test Method for Thermal Transmittance of Textile Materials
   d. ASTM D3005 Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
   e. ASTM D 5034 Breaking Force and Elongation of Textiles Fabrics (Grab Test)

   a. NFPA 130 Standard for Fixed Guideway Transit Systems
   b. NFPA 70 National Electric Code (NEC)

4. National Electrical Contractors Association (NECA):
   a. NECA 1 Standard Practices for Good Workmanship in Electrical Contracting

5. National Electrical Manufacturers Association (NEMA):
   a. NEMA WC 70 Non-Shielded Power Cable 2000 V or Less
1.03 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures.

B. Submittal Requirements: Before installation of wire and cable, submit the following information for each type and size of wire and cable:

1. Manufacturer of wire and cable, and certificate of compliance;
2. Number and size of strands composing each conductor;
3. Average overall diameter of finished wire and cable;
4. Minimum insulation resistance in megohms per 1000 feet at 30 degrees C ambient;
5. Jacket composition and thickness in mils;
6. Total number of conductors per cable;
7. Shield material (if any) and thickness;
8. Conductor resistance and reactance in ohms per 1000 feet at 25 degrees C ambient; and
9. Conductor ampacity at 30 degrees C ambient for 600 V wire and cable.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

B. Store wire and cable in secure and dry storage facility, in accordance with NECA 1.

PART 2 - PRODUCTS

2.01 MATERIALS

A. WIRE AND CABLE MARKINGS

1. Verify that wire and cable markings are in accordance with applicable NEMA and National Electrical Code requirements.

B. 600 VOLT SINGLE CONDUCTOR CABLE

1. Conductor Material: ICEA stranded or solid copper meeting requirements of ASTM B 3, soft drawn.

2. Conductor Type:
   b. Size 10 AWG and Larger: Class B stranded.
   c. Size 14 to 1/0 AWG: Type XHHW-2, cross-linked polyethylene insulated in accordance with NEMA WC 70.
d. Size 2/0 AWG and Larger: Type XHHW-2, cross-linked polyethylene insulated in accordance with NEMA WC 70 or type RHH/RHW, ethylene-propylene-rubber-insulated in accordance with NEMA WC 70.

3. Temperature Rating: Use cables temperature rated not less than 75 degrees C.

4. Fire-Retardant Properties: Ensure that power cable for emergency fans and related equipment; emergency lighting and exit sign cables; and all circuits emanating from a UPS fed panel including the feeders from the UPS to that panel, meet the criteria of NFPA 130. The cable shall have a minimum one hour fire resistive rating in accordance with UL 2196. This requirement also applies to the main feeders emanating from the main switchgear and terminating in panels that feed the above listed equipment.

5. All conductors in exposed or surface mounted raceway in air plenums shall be listed fire-resistive cables in accordance with UL 2196.

6. Insulation Rating: 600 V.

C. MULTIPLE CONDUCTOR, LOW-VOLTAGE CABLE

1. Provide multiple conductor cable conforming to NEMA WC 70, approved for use in cable tray, with the following additional requirements:
   a. Number of Insulated Conductors: As indicated.
   b. Provide multiple conductor cable for all power applications, except receptacles when installed in cable tray for sizes up to 4/0 AWG, as indicated.
   c. Insulation: As specified above for single conductor cable.
   d. Overall Covering: Cable shall be jacketed over the insulation.
   e. Multiple conductor for control wire shall be minimum of 14 AWG stranded copper.
   f. Insulation Rating: 600 V.

2. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

D. FIXTURE WIRE

1. Provide fixture wire conforming to the following requirements:
   a. Type: SF-2 silicone rubber insulated.
   b. Conductor: Stranded copper conductor 16 AWG or larger as indicated.

E. BARE CONDUCTOR

1. Use ASTM B 3, Class B stranded, annealed soft-drawn copper conductor unless otherwise indicated. Size as indicated. Use bare conductor for ground wire only.

F. COLOR CODING OF CONDUCTORS (600 V)
1. Identify individual conductors of multi-conductor cables by means of solid colors, stripes, or printing, unless otherwise approved by the Resident Engineer.

2. Jacket Printing: Use cables which have printing on the jacket or a printed marker tape under the jacket. Verify that jacket printing includes, but is not be limited to, the number of conductors, conductor size, voltage rating, name of manufacturer, manufacturer's type, and date of manufacture; and that this information appears at intervals of not more than 30 inches.

3. Footage Marker Tape: Provide cables with a footage marker tape under the jacket or hot-foil footage printing on the jacket.

4. Power Cables: Conform to the following color coding for power cables:

<table>
<thead>
<tr>
<th>Conductor</th>
<th>480Y/277 V</th>
<th>208Y/120 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Brown</td>
<td>Black</td>
</tr>
<tr>
<td>Phase B</td>
<td>Orange</td>
<td>Red</td>
</tr>
<tr>
<td>Phase C</td>
<td>Yellow</td>
<td>Blue</td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>

5. Use solid color insulation or solid color coating for branch circuit phase conductors 10 AWG and smaller and all neutral and equipment ground conductors.

6. Use a background color other than white or green for phase conductors with colored tracers.

7. For solid color coatings and tracers, use a strongly adherent paint or dye not injurious to the insulation which will not be obliterated by pulling into a conduit or raceway.

8. On-site coloring of ends of conductor may be permitted by the Resident Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color-coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is noninjurious to the insulation.

G. CONNECTORS AND INSULATING TAPES

1. Splice and Terminal Connectors:
   a. Provide termination fittings listed for use with the cable furnished, NEMA standard.
   b. For termination and splice fittings on No. 10 and smaller conductors use compression type or insulated, expanding-spring type. Make wire splices either self-insulating or provided with an insulating cap or heat-shrink insulating sleeve.
   c. For termination and splice fittings on No. 8 and larger conductors use tool-applied compression connectors of material and design compatible with the conductors for which they are used.
d. For terminal connectors on conductors size No. 4/0 and larger use long-barrel, double-compression type, and furnish with two NEMA standard bolt holes in the tongue.

2. Insulating Material for Splices and Terminations:

a. Basis-of-Design Products: Subject to compliance with requirements, provide epoxy sealed splices at all open bottom junction boxes with the following or approved equals.
   
   1) 3M: “Scotchcast Flexible Splice Kit 82-F1” or “Wye Resin Splice Kit 82-B1.”

b. Description: Factory-fabricated connectors and splices of size, ampacity rating, and class for application and service indicated.

3. For general use electrical insulating tape use vinyl plastic with rubber based pressure sensitive adhesive, which is pliable from temperatures of minus 18 degrees C to 105 degrees C. Verify the tape has the following minimum properties when tested in accordance with ASTM D 3005:
   
a. Thickness: 7 mils.
   
b. Breaking Strength: 15 pounds per inch.
   
c. Elongation: 200 percent.
   
d. Dielectric Strength: 10 kV/mil.
   
e. Insulation Resistance (Direct method of electrolytic corrosion): 10 MW.

4. For rubber electrical insulating tape for protective overwrapping use silicone rubber with a silicone pressure-sensitive adhesive. Verify the tape has the following minimum properties when tested in accordance with ASTM D1000:
   
a. Elongation: 525 percent.
   
b. Dielectric Strength: 13 kV.
   
c. Insulation Resistance (Indirect Method of Electrolytic Corrosion): 10 MW.

5. For Arcproof tape use flexible, conformable organic fabric, coated one side with a flame-retardant flexible elastomer, self-extinguishing, with the following minimum properties:
   
   
b. Tensile Strength, ASTM D 5034: 50 pounds per inch.
   
c. Thermal Conductivity, ASTM D 1518: 0.0478 Btu (h/ft²/F).
   
   
e. Mark each tape package to indicate shelf-life expiration date.

H. CONDUCTOR BUNDLING STRAPS

1. Provide conductor bundling straps formed from self-extinguishing nylon having a temperature range of minus 40 degrees F to 185 degrees F.
2. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.

3. Ensure all wire and cable ties installed outdoors and in exposed locations are made of ultraviolet-resistant material.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Furnish wires and cables to the site in unbroken standard coils or reels upon which a tag is attached bearing the manufacturer’s name, trade name of the wire, and listing information.

B. Complete wiring as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the manufacturer.

D. Bundle cable and conductors neatly and securely with nylon straps in branch circuit panelboards, cabinets, control boards, switchboards, and motor control centers. Bundle power cables separately from control cables.

E. Install motor feeders, service connections, and extensions in accordance with the referenced codes. Install motor feeder in liquid-tight flexible conduit of 18 inches minimum length at motor conduit box.

F. For wire pulling, comply with NECA 1 and the following:

1. Install wire and cable in conduit as indicated. Do not use block and tackle or other mechanical means for pulling conductors smaller than 2 AWG in raceways.

2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer.

3. Do not exceed the manufacturer’s recommended pulling tension. For conduit runs with three bends, and cable sized larger than 2 AWG, provide cable tension measuring equipment and record the highest cable tension. Notify Resident Engineer 48 hours prior to such pulling operations and adjust schedule as necessary to permit observation.

4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.

G. Power and Control Cable Installation in Manholes and Pullboxes: Route cables along the manhole or handhole walls providing the longest possible slack. Form cables closely parallel to the walls. Prevent cable interference with duct entrances, and support cables on brackets and cable insulators, spaced at a maximum of 4 feet. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, the existing locations of cables, cable supports, and grounding shall be modified as required to provide a properly arranged and supported installation.
H. Splices and Terminations:

1. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets. Splice in multiconductor, medium-voltage cables in accordance with the cable and splice-kit manufacturers’ recommendations. Insulate splices to a level equal to that of the cable.

2. Use splice and terminator installation tools and installation techniques recommended by the manufacturer.

3. Mechanical hand tools, with dies for each conductor size as recommended by the manufacturer, may be used on conductor sizes through #6 AWG.

4. For conductor sizes larger than #6 AWG, use hydraulic tools with hexagonal or circumferential dies as recommended by the manufacturer.

5. Use compression tools which permanently imprint die information on the completed connection.

6. Use continuous lengths of wire and cable shall between power source and equipment. Where splices are required, make them only in approved fittings or junction boxes. Splices are subject to approval by the Resident Engineer. Follow manufacturer’s instructions in splicing wire and cable.

7. Fixture Wire: Make splices in lighting circuits with insulated crimp-type connectors.

8. Control Cables: Terminate each wire held with screw-type terminals using an insulated sleeve (nylon), ring-tongue-type or locking spade-type, crimp-on lugs.

3.02 FIELD QUALITY CONTROL

A. Inspect wire and cable for physical damage and proper connections.

B. Perform continuity test on power and equipment branch circuit conductors.

C. Verify phasing for circuits to three-phase loads.

D. Test for insulation resistance in accordance with Section 26 08 00, Commissioning of Electrical Systems.

1. Test after splices and terminations are complete. Do not connect equipment to the cable system during tests.

2. Acceptance Criteria for 600V wire and cable: 10,000,000 ohms

3. Test Failure: In case insulation resistance values are unacceptable, correct deficiency and retest. If the test fails again, replace the entire wire or cable segment.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for power system grounding, electrical equipment and raceway grounding and bonding, and bonding of metallic objects near the trackway.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 05 12 00, Structural Steel Framing
2. Section 12 93 00, Site Furnishings
3. Section 26 05 25, Wire and Cable
4. Section 26 08 00, Commissioning of Electrical Systems
5. Section 32 31 13, Chain Link Fences and Gates

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents:

   a. ASTM B 3  Specification for Soft or Annealed Copper Wire
   b. ASTM B 187  Specification for Copper Bar, Bus Bar, Rod and Shapes

2. Institute of Electrical and Electronics Engineers (IEEE):
   a. IEEE 837  Qualifying Permanent Connections Used in Substation Grounding

1.03 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures.

B. Shop Drawings: Where grounding system is not detailed on the Contract Drawings, submit shop drawings showing locations of ground rods, grounding connections, locations of embedded and buried grounding conductors and locations of stub outs and pigtails for future connections to the grounding system by others. Indicate on drawings the locations of test points to measure grounding resistance.

C. Product Data: Submit manufacturers’ product data of grounding materials and coal-tar epoxy protective coating.
1.04 QUALITY ASSURANCE
A. Qualifications: Provide training for electricians involved in the selection, maintenance and operation of exothermic welding materials and equipment. Ensure resistance testing is performed by personnel trained in grounding system installation and testing.

1.05 DELIVERY, STORAGE AND HANDLING
A. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
B. Store equipment and materials in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Ground Rods: Medium carbon steel core, copper-clad by the molten weld casting process, size of 3/4-inch diameter by 10 feet long or as indicated.
B. Bare Conductors: ASTM B 3, Class B stranded, annealed copper conductor, unless otherwise indicated, size as indicated.
C. Bus Bar: ASTM B 187, 98 percent conductivity copper, size as indicated.
D. Single Conductor Insulated Wire: Refer to Section 26 05 25, Wire and Cable.
E. Terminal Lugs: Exothermically-welded or compression-type approved for the application.
F. Jumpers: Tin-plated copper, braided, flexible jumper.
G. Exothermic Welding System: Provide dual-component exothermic welding system with molds and accessories of a single manufacturer. Erico, Thermoweld, or approved equal.
H. Compression Connections: Provide connectors and compression tools from a single manufacturer. Use Connectors which have an inspection port for checking proper conductor insertion.
I. Compression Tools: For field quality control, use compression tools that emboss the die index number into the connector as the crimp is completed.
J. Coal Tar Epoxy Coating: Coal tar polyamide epoxy, high-build corrosion resistant coating. Tnemec Series 46H-413 ‘High-build Tneme-Tar or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Ground Connections:
   1. Buried or embedded connections: Exothermically welded or compression-type terminal lugs using materials qualified in accordance with IEEE 837. Do not bury or embed bolted connections.
   2. Above-ground connections: Exothermically welded or compression-type terminal lugs using materials qualified in accordance with IEEE 837. Make connections in
accordance with the manufacturer’s instructions. Bolted connections are permitted only in secured locations not accessible to the public.

3. Make connections in accordance with the manufacturer’s requirements. Clean ferrous structures and piping and coat with a coal-tar epoxy for a distance of 6 inches from the grounding attachment point.

4. Do not bond buried metallic piping systems or structures to grounding electrode systems unless specifically directed.

5. Provide continuous ground conductor or splice using connections qualified in accordance with IEEE 837.

6. For connections from a grounding bus to grounding electrode system, provide a NEMA lug fastened with stainless steel bolts and locking hardware. Provide exothermically-welded or compression lug on grounding electrode conductor.

7. Provide waterstops on stranded, ground conductors where they enter a structure.

B. Ground Rods:

1. Bury ground rods vertically with top of rod a minimum of 12 inches below grade or as indicated. If extensive rock formation is encountered, relocate ground rods to a new location as approved by the Resident Engineer.

2. Interconnect ground rods with minimum No.1 AWG stranded, bare copper cable or as indicated.

C. Station Electrical System Grounding Electrode:

1. Provide ground ring with multiple ground rods or concrete-encased grounding electrode system. Unless otherwise indicated, conductors of the grounding ring shall be buried in native fill not less than 36 inches below final grade.

2. Provide minimum No.1 AWG stranded, bare copper conductor for grounding ring and concrete-encased electrode.

3. Measure grounding electrode resistance of the installed system and provide additional bonded ground rods as necessary to meet the maximum acceptable ground resistance as specified herein.

D. Traction Power Substation and Tie Station Grounding Electrode:

1. Provide grounding grid with multiple ground rods or concrete-encased electrode as indicated on Contract Drawings. Unless otherwise indicated, bury conductors of the grounding grid in native fill not less than 36 inches below final grade.

2. Measure grounding electrode resistance of the installed system and provide additional bonded ground rods as necessary to meet the maximum acceptable ground resistance as specified herein.

E. Communications and Train Control System Grounding Electrode:

1. Provide two ground rods separated by 8 feet and bonded to communications and train control systems cabinets and bond to electrical system grounding electrode with No. 6 insulated copper conductor. Isolated connections to structure reinforcing/ concrete-encased grounding electrode system are also acceptable.
2. Measure grounding electrode resistance of the installed system and add additional bonded ground rods as necessary to meet the maximum acceptable ground resistance as specified herein.

F. Equipment Grounding Requirements:

1. Install a bare copper equipment-grounding conductor in each raceway and bond to metallic raceways and boxes at access and pull points.

2. Size equipment grounding conductors in accordance with the National Electrical Code to provide adequate conduction path for ground faults. Increase size as required to allow for circuit voltage drop.

3. Ground metallic raceways, boxes, cabinets, exposed expansion joints, lighting fixtures, motors, transformers, and receptacles. Provide grounding bushings or compression connectors attached with machine screws for bonding.

G. Facility Bonding Requirements: Bond metallic objects within 15 feet of the track centerline to the station grounding electrode. This includes but is not limited to station structures, equipment cabinets, handrails, fences, bollards, cable, chain barriers, or art objects. Do not make bonding connections below or above ground at an inconspicuous location on the object. Protect exposed connections and grounding conductor from damage and theft. Bond continuous metallic objects, such as fences, at a minimum, every 30 feet.

H. Trackway Bonding Requirements: Bond metallic objects within 15 feet of the track centerline to individual ground rods. Bond continuous metallic objects, such as fences, at a minimum, every 30 feet. Provide ground rods where necessary for this purpose.

3.02 FIELD QUALITY CONTROL

A. Test the installed grounding system in accordance with Section 26 08 00, Commissioning of Electrical Systems

B. Acceptance Criteria:

1. Station Grounding System: 10 ohms, maximum.


3. Traction Power Substation or Tie Station Grounding Electrode: 5 ohms, maximum.


END OF SECTION
SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing and installing electrical raceways including conduit, duct and cable tray, outlet, junction and pull boxes, and electrical cabinets.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 26 05 26, Grounding and Bonding For Electrical Systems
2. Section 26 05 43, Underground Ducts and Raceways for Electrical Systems
3. Section 26 05 00, Common Work Results for Electrical

1.02 REFERENCES
A. This Section incorporates by reference the latest revision of the following documents

1. American National Standards Institute (ANSI):
   a. ANSI C80.1 Rigid Steel Conduit - Zinc Coated

   b. ASTM A 153/A 153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

3. National Electrical Contractors Association (NECA)
   a. NECA 1 Standard Practices for Good Workmanship in Electrical Contracting

4. National Electrical Manufacturers Association (NEMA):
   a. NEMA FG 1 Fiberglass Cable Tray Systems
   b. NEMA RN 1 Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   c. NEMA TC 2 Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
   d. NEMA TC 3 PVC Fittings for Use with Rigid PVC Conduit and Tubing
   e. NEMA TC 6 & 8 PBC Plastic Utilities Duct for Underground Installations
f. NEMA TC 14 Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

g. NEMA VE 1 Metallic Cable Tray Systems

h. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

5. National Fire Protection Association (NFPA):

   a. NFPA 70 National Electrical Code

   b. NFPA 130 Fixed Guideway Transit and Passenger Rail Systems

1.03 SUBMITTALS

   A. Procedure: Section 01 33 00, Submittal Procedures.

   B. List of Materials: Submit a list of materials proposed for use. Give name of manufacturer, brand name, and catalog number of each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by Contract Specifications Section and Article numbers.

   C. Compliance with Applicable Standards:

      1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASTM and NEMA, submit evidence of conformance. The label or listing of the specified agency will be acceptable evidence.

      2. Instead of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, stating that the items have been tested and that the units conform to the specified standard.

   D. Shop Drawings:

      1. Submit shop drawings showing the exact location and arrangement of conduits, cabinets, and pullboxes installed under this Contract. Submit drawings with ample time to prevent delays in the Work.

PART 2 - PRODUCTS

2.01 MATERIALS

   A. CONDUIT and Duct

      1. Galvanized Rigid Steel (GRS) Conduit and Accessories: ANSI C80.1; hot-dip galvanized inside and out after threading; each length shall bear UL label.

         a. Fittings and Accessories:

            1) Bushings: Nylon-insulated, metallic, grounding type.

            2) Conduit straps, clamps, and clamp backs: Galvanized malleable iron.

      2. PVC-Coated GRS Conduit (PVC/GRS): NEMA RN 1, with corrosion resistant internal coating.
a. Shipping: Thread protectors installed on both ends of conduit, with couplings packaged separately.

3. PVC Electrical Conduit and Fittings: NEMA TC 2, EPC-40-PVC; heavy wall, high impact strength, rigid PVC.
   a. Fittings: NEMA TC 3, EPC-40-PVC.

4. Plastic Utilities Duct: NEMA TC 6 & 8, Schedule 20 type EB.

5. Epoxy and Phenolic Fiberglass Conduit and Fittings: NEMA TC 14; standard-wall
   a. Conduit joints and fittings: Tapered or untapered; all of one type.

6. Innerduct
   a. Separate innerduct raceways
      1) 1-inch inside diameter smooth- or longitudinal-ribbed-wall, flexible PVC or polyethylene tubing with 0.125-inch wall thickness.
      2) Suitable for pulling into conduit and provided with fittings necessary to make up a complete raceway system.
      3) Acceptable manufacturer: Carlon, Pyramid, or approved equal.

7. Liquidtight Flexible Metallic Conduit and Fittings:
   a. Core: Flexible galvanized steel with a continuous copper bonding conductor spiral wound between the convolutions.
   b. Jacket: Extruded liquidtight plastic or neoprene; moisture- and oil-proof, capable of conforming to the minimum radius bends of flexible conduit without cracking; self-extinguishing with low halogen containing material.
   c. Fittings: Zinc-coated.

8. Conduit Expansion Fittings:
   a. Factory installed packing ring, designed to prevent the entrance of moisture.
   b. Pressure ring.
   c. Grounding ring or a grounding conductor for metallic expansion couplings.
   d. Use fittings which maintain a constant inside diameter in every position and provide a smooth wireway for protection of wire insulation.

B. GALVANIZED STEEL FIELD COATING
   1. Organic cold galvanizing coating: minimum 95 percent metallic zinc by weight in dried film; manufactured by ZRC Products Company, or approved equal.

C. OXIDE INHIBITING JOINT COMPONUDS
   1. Petroleum-based compound with evenly suspended zinc particles.
2. Burndy “Penetrox A” or approved equal.

D. CONDUIT TRAPEZE HANGERS AND FRAMING CHANNEL

1. Hangers:
   a. Two or more steel hanger rods, a steel horizontal member, U-bolts, clamps, and other attachments as necessary for securing hanger rods, and conduits.
   b. Capable of supporting a load equal to the sum of the weights of the conduits and wires, the weight of the hanger itself, plus 200 pounds

2. Steel hanger rods: Galvanized, not smaller than 3/8-inch diameter, threaded either full length or for a sufficient distance at each end to permit at least 1-1/2 inches of adjustment

3. Horizontal member:
   a. Structural grade steel, 1-1/2 by 1-1/2 inches or 1-5/8 by 1-5/8 inches, 12 gage, cold-formed, lipped channel, designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments. Ensure nuts and clamps are compatible with the channel.
   b. Two or more channels may be welded together to form horizontal members of greater strength.
   c. Hot-dip galvanized after fabrication in accordance with ASTM A 123/A 123M or ASTM A 153/A 153M, as applicable.
   d. Manufacturer: Unistrut or approved equal.

E. METALLIC CABLE TRAYS

1. Cable Tray: NEMA VE 1, except for modifications indicated.

2. Components: Hot-dip galvanized steel in accordance with ASTM A 123/A 123M, or stainless steel Type 304 or Type 316, as indicated.

3. Dimensions: Use trays with a width of 6 inches minimum and a loading depth of 3 inches minimum. Use trays with an inside nominal depth of 5 inches minimum. Use curved fittings with a 24 inches minimum curve radius, unless otherwise approved by the Resident Engineer.

4. Type: Ladder type or solid bottom type with solid covers, as indicated.

5. Performance Requirements:
   a. Verify the cable tray system is capable of supporting a total cable load of 55 pounds per linear foot for cable tray of 30 inches wide or less and 88 pounds per linear foot for cable tray over 30 inches wide on a maximum span of 8 feet including a static concentrated load of 200 pounds as specified below, with a safety factor of two based on the destructive load, regardless of the type of splice plates or type of span, when tested in accordance with load test procedure specified in NEMA VE 1.
b. Ensure that straight sections and fittings don’t permanently deform under a 200-pound static concentrated load applied vertically along a 4-inch length for both of the following conditions:

1) Load applied to center of one tray section having specified cable load and support spacing. Apply load at midpoint between supports over a splice connection.

2) Load applied to one rung of empty tray section having specified support spacing. Locate the load at midpoint between side rails and supports.

6. Cable Tray Supports:

a. Capable of carrying a working load of 100 pounds per linear foot, with a safety factor of 3.0 when loaded in accordance with NEMA VE 1, Section 3, and tested in accordance with NEMA VE 1, Section 4.

b. Manufactured or fabricated in accordance with the cable tray manufacturer’s recommendations.

F. FIBERGLASS CABLE TRAYS

1. Cable Tray: NEMA FG 1, except for modifications indicated.

2. Conform with requirements of metallic cable trays as applicable to plastic systems.


G. OUTLET BOXES; JUNCTION AND PULL BOXES

1. Provide electrical boxes of the material, finish, type, and size indicated and as required for the location, kind of service, number of wires, and function. For boxes located in tunnels and cross-passages use NEMA 4X stainless steel unless otherwise approved.

2. Not all junction boxes are shown on the plans. Junction boxes and pull boxes shall be installed as necessary by the contractor to aid in pulling wire, and to be in conformance with the NEC. There shall not be more than 270 degrees of conduit bends between pull points per sound transit criteria. Contractor is to coordinate the location of the junction boxes and pull boxes with other trades to ensure that the boxes will remain accessible after all construction is complete.

3. Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used, except that boxes in which, or on which, no devices or fixtures are to be installed shall be equipped with flat or raised blank covers as required.

4. For boxes below 100 cubic inches in size or boxes for embedment in concrete use cast metal. Conform to the requirements for cabinets for boxes over 100 cubic inches in size, except when boxes in interface pull boxes are cast metal with gasketed cast metal covers. Use Type FD boxes for surface mounted wiring devices.

5. Pedestrian type junction boxes shall be used for applications that require a junction box to be embedded in floor concrete or grade. The junction boxes shall be designed to be mounted in sidewalks and other flat concrete surfaces. The
boxes shall have checkered covers and be made to withstand pedestrian traffic. These boxes shall be provided with a flat, neoprene gasket, attached to the cover. This box shall be cast iron with stainless steel cover screws. The finish shall be hot dip galvanized.

6. Ensure covers are the same thickness as boxes and are secured in position by means of No. 10-24 stainless steel machine screws. Arrange covers to be readily and conveniently removed.

7. Ensure Junction boxes are galvanized inside and outside. Where outlet boxes are used as junction boxes, do not use boxes smaller than 4 inches square by 1-1/2 inches deep. Provide such boxes with flat blank covers.

8. For exposed installation, use outlet and switch boxes made of cast metal, not smaller than 4 inches square by 2-1/8 inches deep.

9. Provide brackets, supports, hangers, fittings, bonding jumpers, and other installation accessories as required.

10. Provide neoprene gaskets 1/8-inch thick for boxes subjected to weather.

11. Ground each box as specified in Section 26 05 26, Grounding and Bonding For Electrical Systems.

12. Ensure boxes for systems control and communications applications conform to NEMA 250 Type 4 and shall be provided with NEMA Type 4 labels.

13. All junction boxes for use in escalator or elevator pits shall be rated NEMA 12.


H. Cabinets

1. Cabinet Boxes: Galvanized or stainless steel, size as noted on Contract Drawings. Provide white, galvanized steel interior mounting panel for mounting terminal blocks and relays in interface terminal cabinets.

2. Cabinet Fronts: Steel, surface or recessed type as required for the application with continuous hinge and flush lock. Supply locks for cabinets from a single manufacturer with standard key blank that are field-keyable.

3. Electrical Service and Distribution Cabinets: Stainless steel with non-directional brushed finish and accessories shown on Contract Drawings. Provide metering provisions meeting the requirements of the serving electric utility for Service Cabinets. Provide lock mechanism as required above.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. General Requirements

1. Install electrical raceway, boxes and accessories in locations as indicated, in accordance with NFPA 70 and NECA 1, to provide a complete and operable system.
2. Ensure conduit, support fittings, boxes and conduit fittings are of compatible materials that will not corrode when subjected to moisture or standing water.

3. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location.

4. Install conduit so as to avoid conflicts with other work. Install horizontal raceways close to the ceiling or ceiling beams and above water or other piping wherever possible.

B. Conduit and Duct Type Requirements

1. Above grade exterior or potentially-wet areas: GRS or fiberglass conduit.

2. Below grade interior spaces (tunnels, shafts, and tunnel passenger stations): PVC/GRS or fiberglass conduit and accessories.

3. Conduits for emergency loads (such as emergency lighting and fire alarm system): GRS or PVC/GRS.

4. Below grade exterior areas: PVC/GRS conduit, PVC electrical conduit encased in concrete ductbanks, fiberglass conduit, or plastic utility duct encased in concrete ductbanks (see Section 26 05 43, Underground Ducts and Raceways for Electrical Systems).

5. PVC electrical conduit may only be installed where embedded in slabs and walls, or where required in short sections for electrical isolation. Do not leave PVC conduit exposed unless specifically shown on Contract Drawings. Terminate PVC within concrete walls or slabs with a male adapter and PVC/GRS coupling installed flush with the finished surface.

6. Provide PVC/GRS conduit section for transition between an embedded conduit and the above-ground metallic conduit. Ensure that the above-ground PVC-coated metallic conduit extends 1-foot minimum above ground or to box termination, whichever is less.

7. Install liquid tight flexible metal conduit only where required for flexibility such as connections to vibrating equipment and across joints subject to differential movement.

8. Running thread shall not be used.

C. CONDUIT MINIMUM SIZES

1. GRS: 3/4-inch diameter for exposed locations and 1-inch diameter for embedded locations.

2. PVC/GRS: 3/4-inch diameter for exposed locations and 1-inch diameter for embedded locations.

3. PVC Conduit: 3/4-inch diameter for exposed locations, 1-inch diameter for embedded locations.

4. EB Duct: 4-inch diameter.

5. Fiberglass Conduit: 3/4-inch diameter for exposed locations and 1-inch diameter for embedded locations.
7. Liquidtight Metallic Flexible Conduit: 1/2-inch diameter.

D. Conduit and Duct Bends

1. Install conduit runs with not more than 270 degrees total bends between pull boxes. Where more bends are required in a particular run, install pull boxes as required to facilitate pulling conductors even if not indicated.

2. Minimum Bend Radius Within Structures: In accordance with National Electrical Code Chap. 9, Table 2

3. Minimum Bend Radius Underground
   a. 1-inch conduit: 18-inch radius
   b. 1-1/4-inch conduit: 20-inch radius
   c. 1-1/2-inch conduit: 22-inch radius
   d. 2-inch conduit: 27-inch radius
   e. 2-1/2-inch conduit: 30-inch radius
   f. 3-inch conduit: 30-inch radius
   g. 3-1/2-inch conduit: 33-inch radius
   h. 4-inch conduit: 36-inch radius
   i. 5-inch conduit: 42-inch radius

4. PVC Conduit Bending Restrictions
   a. Hot bend bends with radii less than 100 feet using a heater recommended by the conduit manufacturer. Bends with radius 100 feet or larger may be cold bent.
   b. Do not bend PVC conduit used in ductbanks with a radius less than 6 feet.

5. EB Duct Bending Restrictions
   a. Do not hot bend Type EB duct.
   b. Type EB duct may be cold bent for slight offsets or changes in direction. Do not cold bend EB duct for radii less than 120 feet.

E. Conduit and Duct installation

1. Install conduit in accordance with NFPA 130, local codes and ordinances and as indicated.

2. Prevent material and water from entering the conduit, or pull and junction boxes. Provide threaded cap or similar closure designed for the purpose on conduits that are not terminated immediately. Tape is not acceptable for temporary sealing.
3. Match extensions to existing work to existing size.

4. Where conduit passes across an expansion or contraction joint in the structure, install the conduit at right angles to the joint, and provide liquid tight flexible metal conduit or an approved conduit expansion/deflection fitting at the joint.

5. Provide expansion fittings in conduit runs where required to compensate for thermal expansion.

6. Where conduit is exposed to different temperatures, seal the conduit to prevent condensation and passage of air from one area to the other.

7. If PVC conduit or type EB duct is not fully encased at one time, leave one end of the raceway free until encasing is restarted, or a PVC expansion joint is installed in the run.

8. When field threading of conduit is required, clean threads with a solvent to remove oil as recommended by coating manufacturer, and coat threads with organic cold galvanizing coating, in accordance with manufacturer's instructions.

9. Coat threads with oxide inhibiting compound for metal-to-metal threaded joints. Take care that compound is not present on interior of conduit after installation.

10. Seal conduits with watertight duct sealing system, where waterproofing is required.

11. Install liquid tight flexible metal conduit so that liquids tend to run off the surface and do not drain toward fittings. Provide sufficient slack to reduce the effects of vibration.

12. Terminated stubbed conduits for future in a male pipe plug with provisions for pulling cord attachment. Install wrench-tight into the flush coupling.

13. Mandrelling: As each section of a duct line is completed between pullboxes, use testing mandrel not more than 1/4 inch less than the size of the conduit and brush to clear ducting.
   a. Draw mandrel through each conduit, after which draw through a brush with stiff bristles having a diameter of 1/2 –inch greater than the internal diameter of the duct, until the conduit is clear of particles of earth, sand, or gravel.
   b. Install conduit caps or plugs immediately thereafter.
   c. Notify the Resident Engineer prior to mandrelling any conduit.
   d. Submit a written report providing a conduit identification number, size, material, location, the type and size of mandrel used, and indicate whether the conduit is tagged. Indicate on the report the acceptance date and initials of the Resident Engineer and the Contractor's foreman.

14. Install 1/8-inch or larger diameter polypropylene pulling cord in ducts including innerducts. Ensure accessibility for conduits with threaded caps, or fasten each cord to pull iron anchorage in pull box, manhole, or vault with 2 feet minimum slack.

F. Conduit Grounding And Bonding
1. Install metallic conduits to be electrically and mechanically continuous and connected to ground by bonding to the grounding system.

2. In dry areas, provide two locknuts, one inside and one outside of box or enclosure, for rigid conduit terminating at steel box, panelboard, cabinet, or similar enclosure. In exposed areas and damp and wet locations provide threaded hubs with sealing o-rings at conduit terminations.

3. Terminate the conduit in appropriate boxes at motors, switches, outlets, and junction points.

4. See Section 26 05 26, Grounding and Bonding, for further requirements.

G. Raceway Support

1. Support individual wall mounted horizontal conduits not larger than 1 inch in diameter by means of one-hole conduit straps with back spacers or individual conduit hangers.

2. Space conduits installed against concrete surfaces 1/4 inch away from the surface by clamp backs or other approved means.

3. Support individual horizontal conduits larger than 1-inch in diameter by individual hangers and forged steel conduit strap for vertical runs.

4. Conduit Hangers:
   a. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the hanger or channel insert member by U-bolt, one-hole strap, or other specially designed and approved fastener suitable for use with the hangers or channel inserts.
   b. Support conduit using conduit hangers anchored to the structure. Verify suitability of structure for anchoring with Resident Engineer.

5. Apply cold galvanizing coating to the field-cut ends of steel hanger rods and steel channel.

H. OUTLET, JUNCTION, AND PULL BOXES

1. Securely attach outlet, junction, and pull boxes to the structure. Do not use conduits entering the box as supports for the box.

2. Mount outlet, junction, and pull boxes so as to prevent moisture from entering or accumulating within the boxes.

3. Junction and Pull Boxes:
   a. Install so that covers are readily accessible after completion of the installation.
   b. Do not install boxes above suspended ceilings, except where the ceiling is of the removable type or where definite provisions are made for access to each box.

I. CABLE TRAYS
1. Install cable trays as indicated using approved fittings and adequately supporting the complete system.

2. Provide anti-sway brackets on horizontal tray assemblies in accordance with approved Seismic Bracing and Anchorage Plan (see Section 26 05 00, Common Work Results for Electrical).

3. Connect each isolated cable tray system or the entire tray system to the building equipment grounding system with a bare copper conductor in accordance with National Electrical Code.

4. Provide expansion/deflection fittings in cable tray installations where they cross structure expansion joints and to accommodate differential expansion between cable tray and structure. Bond metallic cable trays across expansion/deflection fittings.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for providing nameplates, wire and cable markers, and conduit color coding.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

   1. Section 09 90 00, Painting and Coating: Identification of conduit by system

1.02 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Submit manufacturer’s product data for mounting adhesive.

C. Submit schedule for nameplates.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Nameplates: Engraved three-layer melamine laminated plastic, not less than 3/32-inch thick, black letters on a white background.

B. Wire and Cable Markers:

   1. Non-fading, plastic, printed sleeve labels.

   2. Non-fading, plastic, printed cable tag with holes for attachment to cable with plastic cable ties.

C. Mounting Screws: Stainless steel machine screws.

D. Mounting Adhesive: Permanent.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Degrease and clean surfaces to receive nameplates.

B. Install nameplates parallel to equipment lines.
C. Secure nameplates to equipment fronts using screws or adhesive. Secure nameplate to inside face of recessed panelboard or cabinet doors in finished locations.

3.02 CONSTRUCTION

A. IDENTIFICATION SCHEDULE

1. Conductors: Provide sleeve wire markers on each conductor in panelboard, gutters, pull boxes, manholes, and at load connection. In gutters, pull boxes, and manholes, if cables are not spliced, a cable tag may be used. Attach tag securely to cable with plastic cable tie.
   a. Power and Lighting Circuits: Identify with branch circuit or feeder number.
   b. Control Wiring: Identify with control wire number as indicated on the Contract Drawings.

2. Provide nameplates of minimum letter height as scheduled below.
   a. Panel boards, Switchboards, Uninterruptible Power Supplies, Motor Control Centers, Lighting Controllers: 3/8 inch, identify equipment designation; 1/4 inch, identify voltage rating and source.
   b. Disconnect Switches: 3/8 inch, identify equipment designation; 1/4 inch, identify voltage rating, source, and load served.
   d. Motor Starters in Motor Control Centers: 1/4 inch; identify circuit and load served, including location.
   e. Individual Circuit Breakers, Enclosed Switches, and Motor Starters: 1/4 inch; identify load served.
   f. Transformers: 3/8 inch; identify equipment designation. 1/4 inch; identify primary and secondary voltages, primary source, and secondary load and location.
   g. Devices: 1/4 inch; identify device.
      1) Dimmers
      2) Control devices
      3) Pushbutton stations

B. CONDUIT COLOR CODING

1. Coordinate color of paint with Section 09 90 00, Painting and Coating, to identify conduit by system.

2. Medium-Voltage Distribution System: Orange
3. Low-voltage Distribution System: Unpainted or black
4. Fire Alarm System: Red
CONTRACT SPECIFICATIONS

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: commissioning process requirements for electrical systems:
   1. Level 1 commissioning activities for electrical systems
   2. Level 2 commissioning activities for electrical systems
   3. Support for Level 3 commissioning activities related to electrical systems
   4. Support for Level 4 commissioning activities related to electrical systems
   5. Providing qualified personnel to assist in commissioning tests.
   6. Providing equipment, materials, and labor necessary to correct issues found during the commissioning process which fulfill contract and warranty requirements.

B. Related Sections
   1. Section 01 91 13, General Commissioning Requirements for: General commissioning process requirements, including definitions, submittals, scheduling, execution of commissioning activities, and reporting.
   2. Section 25 08 00, Commissioning of Integrated Automation
   3. Section 26 05 25, Wire and Cable
   4. Section 26 05 26, Grounding and Bonding for Electrical Systems
   5. Section 26 11 19, Double-ended Unit Substations
   6. Section 26 24 13, Switchboards
   7. Section 26 24 14, Motor Starters for Tunnel Fire Ventilation Fans
   8. Section 26 29 13, Enclosed Controllers
   9. Section 26 28 15, Enclosed Switches and Fuses
   10. Section 26 33 53, Static Uninterruptible Power Supplies
   11. Section 26 42 50, Tunnel Corrosion Control at Stations
   12. Section 26 51 14, Lighting Systems

C. Cooperate with the Commissioning Authority in the following manner:
1. Allow sufficient time before functional completion date so that test and balance (TAB) and commissioning testing can be completed.

2. Provide labor and material to make corrections when required without undue delay.

3. Coordinate all required support of that equipment which is provided and installed by the Division 14 (Conveying Systems), Division 21 (Fire Suppression), Division 22 (Plumbing), and Division 23 (HVAC) contractors that requires electrical involvement.

1.02 REFERENCES

A. This Section incorporates by reference in individual sections of Division 26 the latest revisions of the following documents and standards. Refer to individual specification sections for greater detail.

1. NACE International
2. Institute of Electrical and Electronic Engineers (IEEE)
3. National Fire Protection Association (NFPA)
4. International Electrical Testing Association (NETA)
5. National Institute of Standards and Technology (NIST)
6. Underwriters Laboratories (UL)
7. American National Standards Institute (ANSI)
8. National Electrical Manufacturer’s Association (NEMA)

1.03 SYSTEM DESCRIPTION

A. Commissioning work includes: Furnish labor and material to accomplish building commissioning as specified in Division 01 Section “General Commissioning Requirements” and herein, including:

1. Provide to the Commissioning Coordinator preliminary O&M information for submittal.

2. Assist the Commissioning Coordinator in developing commissioning activity procedures and data forms submittals for work specified in this Section.

3. Provide information to the Commissioning Coordinator needed for control interface wiring diagrams submittals for the work of this Section.

4. Perform Level 1 commissioning activities specified in this Section, including installation verification, static tests, start-up, component tests, equipment tests, systems tests.

5. Perform Level 2 commissioning activities specified in this Section, including intra-station system interface tests.
6. Provide support for Level 3 commissioning activities, including jointly with the communications system contractor field testing points in the interface terminal strips, being present during level 3 testing with adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise. When material or equipment provided by this Division is found to be in conflict with specified criteria, adjust or replace said material or equipment, with the assistance of manufacturer as needed.

7. Provide support for Level 4 commissioning activities, including providing adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise during pre-revenue testing.

8. Operate equipment and system during commissioning activities as required by the Commissioning Coordinator.

9. Perform and document commissioning tests to verify readiness for commissioning test demonstration. Commissioning tests are specified herein.

10. Correct issues and repeat commissioning tests when results do not meet acceptance criteria.

11. Perform commissioning test demonstration specified herein to verify acceptable performance.

12. Record and submit commissioning test demonstration data and issues.

13. Correct issues and repeat commissioning test demonstration when results do not meet Acceptance Criteria.

14. Attend commissioning meetings as requested by the Commissioning Coordinator.

15. Report any inconsistencies or issues in system operations or performance.

16. Provide personnel to support commissioning test demonstration specified herein as requested by the Commissioning Coordinator.

17. In the event that a commissioning test demonstration fails, assist in determining the cause of failure. Make corrections as necessary.

18. Cooperate with Commissioning Coordinator to make equipment and systems ready for commissioning tests specified herein as early in the construction schedule as possible.

19. Provide factory start-up services for key equipment and systems specified in Division 26. Coordinate this work with the manufacturer and the Commissioning Authority.

20. Complete all phases of work so the system can be started, tested, balanced, and otherwise commissioned. Division 26 has start-up responsibilities with obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment and materials per the contract documents and related directives, clarifications, change orders, etc.

21. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems, if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor.
Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

B. Cooperate with Commissioning Coordinator to accomplish commissioning work on schedule and in coordination with other trades.

1.04 SUBMITTALS

A. Procedures: Refer to Section 01 33 00, Submittal Procedures and Section 01 33 23 Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

1.05 TESTING LABORATORY

A. General: The terms used herein such as Test Agency, Test Contractor, Testing Laboratory, or Contractor Test Company, shall be construed to mean testing firm.

B. The lead, on site, technical person shall be currently certified by NETA in Electrical Power Distribution System Testing.

C. All instruments used by the testing firm to evaluate electrical performance shall meet NETA’s Specifications for Test Instruments.

1.06 TEST REPORTS

A. Prepare test reports, including description of project, description of equipment tested, description of test, test results, conclusions and recommendations, re-testing results, and list of test equipment used and calibration date.

B. Test reports shall be typewritten.

C. Insert a copy of each test report in the operation and maintenance manuals.

1.07 LABELS

A. Upon completion of tests by a testing firm, a NETA label shall be attached to all serviced devices. These labels shall indicate date serviced and the testing company.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. Provide test equipment and instrumentation, including consumable supplies, required to execute commissioning activities. Unless noted otherwise, test equipment and instrumentation remain the property of the Contractor.

B. Standard certified test equipment for commissioning shall be provided by Division 26.

2.02 PROPRIETARY TEST INSTRUMENTS

A. Provide proprietary test instruments or tools required by the equipment manufacturer. Provide and operate the proprietary test instruments or tools as required for commissioning work.
PART 3 - EXECUTION

3.01 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start-up and debug all systems with the division of work. These same technicians shall be made available to assist the Commissioning Coordinator in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., shall be requested and coordinated by the Commissioning Coordinator. Contractor shall ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

3.02 LEVEL 1 COMMISSIONING ACTIVITIES REQUIREMENTS

A. Level 1 commissioning activities scope: Technical requirements for commissioning of electrical systems are specified herein.

B. Provide technicians, instrumentation, and tools to perform commissioning activities in accordance with accepted commissioning activity procedures at the direction of the Commissioning Coordinator.

C. Scope of electrical systems commissioning activities applies to all portions of the electrical systems installation described in the test, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Where sampling is specified, it applies only to the commissioning test demonstration.

D. Preparation

1. Certify that electrical systems, subsystems, and equipment have been completed, calibrated, and started; and are operating in accordance with Contract Documents.

2. Ensure that all enclosures for electrical equipment are clean and debris free.

3. Testing Instrumentation: Install measuring instruments and logging devices to record test data in accordance with accepted commissioning test procedures as directed by the Commissioning Authority.

4. Certify that electrical systems instrumentation and control systems have been completed and calibrated; are operating according to the Contract Documents; and that pretest set points have been recorded.

5. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions) in accordance with accepted commissioning test procedures as directed by the Commissioning Coordinator.

E. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

F. Tests will be performed using design conditions whenever possible.

G. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Provide equipment to simulate loads.
simulated conditions in accordance with accepted commissioning test procedures as
directed by the Commissioning Coordinator. Document simulated conditions and
methods of simulation. After tests, return settings to normal operating conditions.

H. Request approval to alter set points when simulating conditions is not practical.

I. Request approval to alter sensor values with a signal generator when design or
simulating conditions and altering set points are not practical.

J. If tests cannot be completed because of a deficiency outside the scope of the electrical
system, document the deficiency and report it to the Owner. After deficiencies are
resolved, reschedule tests.

3.03 LEVEL 1 AND LEVEL 2 COMMISSIONING ACTIVITY PROCEDURES

A. Submit level 1 commissioning activity test procedures and data forms for the following
types of commissioning activities, requirements for which are specified herein.

1. Level 1 commissioning activities:
   a. Installation verification
   b. Static tests
   c. Start-up procedures
   d. Component tests
   e. Equipment tests
   f. System tests

B. Cooperate with the Commissioning Coordinator to develop level 2 commissioning activity
test procedures and data forms related to the work of this Division. Provide information as
needed, including interfaces with equipment and systems installed by others.

1. Level 2 commissioning activities:
   a. Intra-station system interface tests

3.04 LEVEL 1 INSTALLATION VERIFICATION CHECKLIST REQUIREMENTS

A. Scope: Installation verification requirements apply to the following:

1. Section 26 05 25, Wire and Cable
2. Section 26 05 26, Grounding and Bonding for Electrical Systems
3. Section 26 11 19, Double-ended Unit Substations
4. Section 26 24 13, Switchboards
5. Section 26 24 14, Motor Starters for Tunnel Fire Ventilation Fans
6. Section 26 29 13, Enclosed Controllers
7. Section 26 28 15, Enclosed Switches and Fuses
8. Section 26 33 53, Static Uninterruptible Power Supplies
9. Section 26 51 14, Lighting Systems

B. Installation Verification Scope: Technical requirements for Installation Verification of electrical systems are specified herein.

C. Installation verification checklist forms shall include the following:

1. Organized to prompt the installer to check off quality criteria for each discrete portion of the Work.

2. Identify the system or features to which the installation verification checklist applies at the top of the form.

3. Section for verification of delivery of accepted materials.

4. Section for condition of materials at delivery.

5. Section for installation. Include manufacturer’s installation instructions.

6. Space at the end of the form for the installer to print their name and company name, fill in the date, and sign or initial.

7. Space to identify the area of work for which the installer is executing the Installation Verification Checklist.

8. Description of the quality criteria as it pertains to the specific work. Include a check-box for each criterion.

D. Quality Criteria: Installation verification checklists shall address the following quality criteria.

1. Make and model match accepted submittals.

2. Equipment is installed without visible damage.

3. Location is as indicated on drawings.

4. Equipment is accessible for maintenance using safe work practices.

5. There is sufficient space to remove and replace components intact without demolishing other work.

E. Fill out and sign installation verification checklists for electrical systems while the Work is being installed. The intent is for the installing tradesperson to fill out and sign the installation verification checklist as work proceeds to improve the quality of the installation. Retain completed installation verification checklists on site for review.

F. Before performing a commissioning test, submit completed installation verification checklists for work included in the commissioning test.

3.05 LEVEL 1 INSTALLATION VERIFICATION

A. Installation verification checklists are required for the following, minimum:

1. 2608-IV-01 Molded-case Circuit Breakers (100 amps and above or feeding mechanical equipment)

2. 2608-IV-02 Low Voltage Power Circuit Breakers
3. 2608-IV-03 Grounding Systems
4. 2608-IV-04 Double-ended Unit Substation
5. 2608-IV-05 Dry-Type Transformers
6. 2608-IV-06 Switchboards
7. 2608-IV-07 Panelboards
8. 2608-IV-08 Motor Control Equipment (FVNR, Soft-Start and VFD)
9. 2608-IV-09 Instrument Transformers
10. 2608-IV-10 Metering and Instrumentation
11. 2608-IV-11 Uninterruptible Power Supplies
12. 2608-IV-12 Lighting Control Panels and Contactors

3.06 LEVEL 1 STATIC TESTS

A. 2608-ST-01: Insulation Resistance
   1. System/Equipment to be tested:
      a. Insulation of conductors rated 100 amperes or greater.
      b. Insulation of conductors for all motor loads.
   2. Functions to be tested:
      a. Insulation resistance
   3. Conditions of the Test:
      a. Perform insulation resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable.
      b. Test duration shall be one (1) minute.
      c. Include in Static Test Procedures and Data Forms submittal.
   4. Acceptable Results:
      a. Insulation resistance tests shall meet the requirements of Table 26 08 00 D13

B. 2608-ST-02: Bolted Connection Torque
   1. System/Equipment to be tested:
      a. Bolted connections for conductors rated 100 amperes or greater.
   2. Functions to be tested:
      a. Bolted connection torque
3. Conditions of the Test:
   a. Perform torque test for each conductor tested and terminated in an overcurrent device or bolted type connection.
   b. Include in Static Test Procedures and Data Forms submittal.

4. Acceptable Results:
   a. Bolted connection torque values shall meet the manufacturer’s published values or the requirements of Table 26 08 00 D12

C. 2608-ST-03: Ground Resistance

1. System/Equipment to be tested:
   a. Grounding resistance
   b. Reference: Section 26 05 26

2. Functions to be tested:
   a. Grounding resistance
   b. Ground continuity

3. Conditions of test:
   a. Test the grounding system by the fall-of-potential method.
   b. Test equipment enclosures, conduit, raceways, exposed expansion joints, lighting fixtures, receptacles, light standards, metal fencing, and other bonded equipment for continuity to the ground system.

4. Acceptable Results:
   a. Station grounding system: 10 ohms, maximum
   b. Communications and Train Control System grounding electrode: 25 ohms, maximum.
   c. Traction Power Substation: 5 ohms, maximum.
   d. Tie Station grounding electrode: 5 ohms, maximum.
   e. OCS Foundation: 25 ohms, maximum.

D. 2608-ST-04: Tunnel Corrosion Control at Stations

1. Equipment/Systems to be tested:
   a. Tunnel corrosion control at stations.

2. Functions to be tested:
   a. Reference: Section 26 42 50, Field Quality Control, for all functions to be tested.

3. Conditions of Test:
a. Reference: Section 26 42 50 for test requirements

4. Acceptable Results:
   a. Reference: Section 26 42 50 for complete details.

E. 2608-ST-05: Lighting Systems Illuminance Levels

1. Equipment/Systems to be tested:
   a. Lighting Levels throughout.

2. Functions to be tested:
   a. Measure footcandle levels at random locations of the floor area. Measurements shall be taken at the following areas and documented.
      1) Platform edge.
      2) Top and Bottom of Stairs.
      3) Elevator Lobbies.
      4) Entrances.
      5) In front of TVM's.
      6) In front of all Emergency Signage.
      7) Along all designated exit routes.

3. Conditions of Test:
   a. Areas are complete and cleaned.

4. Acceptable Results:
   a. Light levels meet criteria for Sound Transit design. See Appendix D, Table D-18 for required footcandle levels.

3.07 LEVEL 1 COMPONENT TESTS (NOT USED)

3.08 LEVEL 1 EQUIPMENT TESTS

A. 2608-E-01: Molded Case Circuit Breakers

1. System/Equipment to be tested:
   a. Molded case circuit breakers serving switchboards, distribution panelboards, panelboards, uninterruptible power supplies, elevators, escalators, and mechanical equipment.
   b. Molded case circuit breakers 100 amperes and greater.
   c. All circuit breakers serving mechanical equipment.

2. Functions to be tested:
   a. Contact resistance.
b. Insulation resistance.
c. Verification of adjustments for final settings.
d. Tightness of electrical connections.
e. Performance characteristics of trip units.

3. Conditions of the test:
   a. Perform a contact resistance test or millivolt drop across contacts at rated current.
   b. Perform an insulation resistance test at 1000 volts dc from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.
   c. Perform adjustments for final settings in accordance with Coordination Study supplied by Contractor.
   d. Perform primary current injection tests to ensure performance characteristics of trip units.
   e. Check trip unit reset operation.

4. Acceptable Results:
   a. Compare microhm or millivolt drop values to adjacent poles and similar breakers. Investigate, correct and re-test deviations of greater than 50 percent.
   b. Insulation resistance shall be per Table 26 08 00 D13
   c. All instantaneous trip times shall fall within manufacturer’s time-current curves or use Table 26 08 00 D7. Circuit breakers exceeding specified trip time at 300 percent of pickup shall be tagged defective.

B. 2608-E-02: Low Voltage Power Circuit Breakers

1. System/Equipment to be tested.
   a. Low voltage power circuit breakers serving switchboards, distribution panelboards, panelboards, uninterruptible power supplies, elevators, escalators, and mechanical equipment.
   b. Low voltage power circuit breakers 100 amperes and greater.
   c. All circuit breakers serving mechanical equipment.
   d. Reference: Section 26 11 19 for additional detail.

2. Functions to be tested:
   a. Contact resistance.
   b. Insulation resistance.
   c. Verification of adjustments for final settings.
d. Tightness of electrical connections.

e. Long-time pickup and Long-time delay time-current characteristics.

f. Short-time pickup and delay.

g. Ground fault pickup and delay.

h. Operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

i. Trip unit reset operation.

3. Conditions of the test:

a. Perform a contact resistance test or millivolt drop across contacts at rated current.

b. Perform an insulation resistance test at 1000 volts dc from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.

c. Perform adjustments for final settings in accordance with Coordination Study supplied by Contractor. Reference Section 26 05 73 Overcurrent Protection Device Study.

d. Perform primary current injection tests to ensure performance characteristics of trip units.

e. Using the settings from the Coordination Study, perform long-time pickup and long-time delay time-current characteristic tests by passing 300 percent rated current through each pole separately.

f. Using the settings from the Coordination Study, determine short-time pickup and short-time delay by primary current injection.

g. Using the settings from the Coordination Study, determine instantaneous pickup by primary current injection using run-up or pulse method.

h. Using the settings from the Coordination Study, determine ground fault pickup and time delay by primary current injection.

i. Verify the correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

j. Check trip unit reset operation.

k. Check key and other interlock safety devices for operation and sequence. Make closing attempts on locked-open and opening attempts on locked-closed devices including barriers and shutters.

l. Test the correct operation of the electrical lockout feature on the tie breaker.

4. Acceptable Results:
a. Compare microhm or millivolt drop values to adjacent poles and similar breakers. Investigate, correct and re-test deviations of greater the 50 percent.

b. Insulation resistance values shall be per Table 26 08 00 D13

c. Trip characteristics of breakers shall fall within manufacturer’s published time current tolerance band including all adjustment factors.

C. 2608-E-03: Ground Fault Protection System

1. System/Equipment to be tested:

a. Ground Fault Protection System at Unit Substation.

b. Reference: Section 26 11 19 for additional detail.

2. Functions to be tested:

a. Adjustable trip and time delay functions.

b. Trip unit reset operation.

c. Electrical lockout feature on the tie breaker.

d. Circuit interrupting device.

e. Relay pickup current.

f. Relay time delay.

g. Ground monitor panel where applicable.

h. Sensor polarity on phase and neutral sensors.

i. Indicator lights and flags.

3. Conditions of test:

a. Set the adjustable trip and time delay functions based on the data generated from the ground fault system study. Reference: Section 26 05 73.

b. Verify trip unit reset operation.

c. Test the correct operation of the electrical lockout feature on the tie circuit breaker.

d. Test correct response of the circuit interrupting device by using ground sensor current injection to measure Relay pickup current.

e. Test correct response of the circuit interrupting device by using ground sensor current injection to measure Relay Time Delay. (Measure at two values above pickup current).

f. Verify proper sensor polarity on phase and neutral sensors.

g. Functionally check operation of ground fault indicator lights and flags for correct indication of ground fault trip.
4. **Acceptable Results:**
   
a. Trip unit resets properly.

b. Electrical lockout on tie circuit breaker operates as intended.

c. Adjustable trip and time delay functions correspond to settings generated in the ground fault system study.

d. Circuit interrupting device operates properly.

e. Ground fault indicator lights and flags operate properly.

D. **2608-E-04: Substation Transformers**

1. **Systems/Equipment to be tested:**
   
a. Unit Substation Transformers

b. All requirements for Commissioning stated in Section 26 11 19.

c. Verify correct phase rotation.

E. **2608-E-05: Dry Type Transformers**

1. **Systems/Equipment to be tested:**
   
a. Dry type transformers

2. **Functions to be tested:**
   
a. Insulation resistance

b. Phase rotation

c. Reference: Section 26 05 17 for additional detail.

3. **Conditions of test:**
   
a. Perform insulation resistance test. Measurements shall be made from winding-to-winding and winding-to-ground.

4. **Acceptable Results:**
   
a. Test voltages and minimum resistances shall be in accordance with Table 26 08 00 D13. Results to be temperature corrected in accordance with Table 26 08 00 D14

b. Verify taps and connect transformer to desired tap.

c. Verify correct phase rotation.

F. **2608-E-06: Double-Ended Unit Substations**

1. **Systems/Equipment to be tested:**
   
a. Double-ended Unit Substations

b. All requirements for Commissioning stated in Section 26 11 19.
c. Verify correct phase rotation.

G. 2608-E-07: Switchboards

1. System/Equipment to be tested:
   a. Switchboards
   b. Distribution Panelboards
   c. Branch Circuit Panelboards

2. Functions to be tested:
   a. Insulation resistance
   b. Phase rotation
   c. Reference: Section 26 24 13 for additional detail.

3. Conditions of test:
   a. Perform insulation resistance test phase-to-phase and phase-to-ground of each bus section.

4. Acceptable Results:
   a. Insulation resistance test voltages and minimum resistances shall be in accordance with Table 26 08 00 - D13.
   b. Phase rotation shall be compatible with the serving utility.

H. 2608-E-08: Motor Control Equipment

1. Systems/Equipment to be tested:
   a. Motor starters (Soft Start) for tunnel fire ventilation fans.
   b. Enclosed motor controllers (general purpose, across-the-line starters)
   c. Variable Frequency Drives

2. Functions to be tested (All motor control equipment):
   a. Insulation resistance
   b. Overload unit operation
   c. Control devices
   d. Phase rotation

3. Additional Functions to be tested (Variable Frequency Drives)
   b. Check motor rotation when operating on the drive and the bypass.
   c. Verify Critical frequencies to be avoided (jumped) during operation by varying speed from minimum to maximum and observing motor for unusual vibration.
d. Operate from remote start-stop and speed control signals.

4. Conditions of test:

a. Measure insulation resistance of each starter phase-to-phase and phase-to-ground with the starter contacts closed and the protective device open.

b. Measure insulation resistance of each control circuit with respect to ground.

c. Test motor overload units (except solid-state type) by injecting primary current through overload unit and monitoring trip time at 300 percent of motor full load current.

d. Perform operational tests by initiating control devices to affect proper operation.

e. Verify installation in accordance with manufacturer’s instructions and in accordance with visual and mechanical inspection requirements.

f. VFD programmable parameter settings established.

g. VFD jump frequency settings coordinated.

h. VFD power failure recovery restart settings coordinated.

i. Motor Soft Starts for Tunnel ventilation fans tested and documented at manufacturing facility.

5. Acceptable Results:

a. Insulation resistance test voltages and minimum resistances shall be in accordance with Table 26 08 00 D13. Manufacturer shall be consulted for test voltage where solid state devices are utilized.

b. Overload tests shall be in accordance with manufacturer’s tolerances. Investigate values in excess of 120 seconds.

b. Phase rotation shall be compatible with the serving utility.

d. Installation in compliance with manufacturer’s procedures and criteria.

e. VFD parameter settings reviewed and signed off by Division 23 and Division 26 contractors. Record all settings for use by Sound Transit.

f. VFD jump settings reviewed and signed off by Division 23 and Division 26 contractors. Record all settings for use by Sound Transit.

g. VFD power failure recovery restart settings reviewed and signed off by Division 23 and Division 26 contractors. Record all settings for use by Sound Transit.

h. Following successful completion of testing specified for Soft Start motors outlined in Specification Sections 23 08 00 and 23 08 00.10 record all settings for use by Sound Transit.

I. 2608-E-09: Instrument Transformers
1. Systems/Equipment to be tested:
   a. Current Transformers
   b. Potential Transformers

2. Functions to be tested:
   a. Insulation resistance
   b. Ratio verification
   c. Polarity
   d. Transformer withdrawal mechanism.
   e. Phase rotation
   f. Fuse sizes on primary and secondary on potential transformers.
   g. Interlock function and contact operation
   h. Grounding and shorting connections
   i. Secondary voltage
   j. Secondary wiring integrity

3. Conditions of test – Current Transformers:
   a. Perform insulation resistance test of the current transformer and current transformer wiring to ground at 500 volts dc for 30 seconds. Disconnect ground connection at ground connection point in the circuit for this test. Do not perform on solid-state devices.
   b. Perform a polarity test of each current transformer.
   c. Perform a ratio verification test of each current transformer. This shall be performed using the voltage method or current method in accordance with ANSI C57.13.1.
   d. Perform a dc dielectric withstand ability test on the primary windings with the secondary windings connected to ground.

4. Conditions of test – Potential Transformers:
   a. Perform insulation resistance tests on voltage transformers, winding-to-winding and windings-to-ground.
   b. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. The test may be performed with a TTR type ratio set.
   c. Perform a ratio test using a Transformer Turns Ratio (TTR) test set or by the voltage comparison method.
   d. Perform a dc dielectric withstand ability test on the primary windings with the secondary windings connected to ground.
e. Verify secondary voltage by energized the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

f. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to proper secondary voltage.

5. Acceptable Results – Current Transformers:
   a. Insulation resistance test voltages and minimum resistances shall be in accordance with Table 26 08 00 - D13. Do not perform this test where solid state devices are utilized.
   b. Polarity is verified correct.
   c. Ratios are verified correct.
   d. DC dielectric withstandability is in accordance with Table 2600.9.

6. Acceptable Results – Potential Transformers:
   a. Insulation resistance test voltages and minimum resistances shall be in accordance with Table 26 08 00 D13. Do not perform this test where solid state devices are utilized.
   b. Polarity is verified correct.
   c. Ratios are verified correct.
   d. DC dielectric withstandability is in accordance with Table 2600.9.
   e. Secondary voltage is verified correct.
   f. Proper potential at all devices.

J. 2608-E-10: Metering and Instrumentation

1. Systems/Equipment to be tested:
   a. Meters

2. Functions to be tested:
   a. Calibration at all cardinal points.
   b. Instrument multipliers.
   c. Tightness of electrical connections.

3. Conditions of test:
   a. Verify accuracy of meters at all cardinal points
   b. Verify all instrument multipliers.
   c. Verify that current transformer and voltage transformer circuits are intact.

4. Acceptable Results:
a. Meter accuracy is verified correct.
b. Instrument multipliers are correct for application

K. 2608-E-11: Uninterruptible Power Supplies – False Load

1. System/Equipment to be tested:
   a. Uninterruptible Power Supplies (UPS)

2. Functions to be tested:
   b. Communications.
   c. Battery supply.
   d. Overload capacity.
   e. Output voltage.
   f. Battery monitoring.
   g. Connection torque.

3. Conditions of test:
   a. Test the manual and automatic operation of the UPS using resistive and
      reactive load banks to simulate all types of load conditions.
   b. Test protective and alarm functions.
   c. Test monitoring capabilities locally and remotely.
   d. Perform battery rundown tests to ensure 90 minute capability.
   e. Test overload capacity of unit at 125% of full load rating for 15 minutes.
      Test at 150% for 30 seconds.
   f. Install power recording meters to record all unit parameters under actual
      load conditions. Meters to be installed at UPS and at panelboard load
      served by UPS. Ten (10) day test duration.

4. Acceptable Results:
   a. Manual and automatic operation of UPS meets design criteria outlined in
      Specification Section 26 33 53.
   b. Remote monitoring location receives correct information regarding Unit
      Status, Unit Parameters and Unit Alarms.
   c. Batteries are able to provide 90 minutes supply to loads under simulated
      full load when the UPS is disconnected from its power source.
   d. Overload capacity meets design criteria.
   e. Power measurement recordings, under actual load conditions, indicate
      satisfactory power quality over complete 10 day test duration.
L. 2608-E-12: Lighting Control Panels

1. Systems/Equipment to be tested:
   a. Lighting Control Panels.

2. Functions to be tested:
   a. Automatic control of lighting loads.
   c. Relay status
   d. Power failure and subsequent Power Up
   e. Daylight controller.
   f. Time control
   g. Network Interface

3. Conditions of the test:
   a. Demonstrate automatic control via controller CPU.
   b. Manually override all automatic functions to control lights regardless of time of day schedule or daylight control requirement.
   c. Verify relay status.
   d. Fail the incoming power to the controller for a period of 30 minutes. Failure of power to take place 10 minutes prior to a programmed change in the lighting control schedule. Restore power to the controller to verify time scheduled events that were to take place during the power outage will be automatically activated.
   e. Demonstrate daylight control by inhibiting the amount of light to the sensor.
   f. Demonstrate time control and the ability to modify schedules.
   g. Demonstrate override control of the light control system via the network lighting controller.

4. Acceptable Results:
   a. Automatic control satisfactorily operates per programmed schedules.
   b. Manual override bypasses normal controller operation and turns on all lights.
   c. Relay status feedback monitors actual current status of each relay.
   d. The controller activates in the correct operating status following failure of power.
   e. Daylight sensor shall respond to diminished lighting. Measure light levels before and after inhibiting sensor.
f. Lighting controller operates satisfactorily following modification of time schedules.

g. Network lighting controller provides complete override control over the lighting system.

M. 2608-E-13: Receptacles

5. Equipment to be tested:
   a. Receptacles standard
   b. Receptacles GFCI

6. Functions to be tested:
   a. Open ground
   b. Reverse polarity
   c. Open hot
   d. Open neutral
   e. Hot and ground reversed
   f. Ground Fault Receptacle Circuit Interrupter when so equipped.

7. Conditions of the test:
   a. Perform all tests with adjustable GFCI and circuit tester
   b. GFCI "TEST" button on receptacle not acceptable for test.

8. Acceptable Results:
   a. Tester indicates correct wiring.
   b. GFCI trips on ground fault current 5 milliamperes or greater.
   c. GFCI does not trip on ground fault current less than 5 milliamperes

3.09 LEVEL 1 SYSTEM TESTS (NOT USED)

3.10 ATTACHMENTS

A. EXAMPLE SYSTEM DESCRIPTION
B. EXAMPLE INSTALLATION VERIFICATION FORM
C. EXAMPLE TEST PROCEDURE
D. TEST PARAMETER TABLES

END OF SECTION
I OBJECTIVES
A. Assure that the Static Uninterruptible Power Supplies (UPS) installed on the project operate properly under both normal and abnormal conditions to supply power to their loads. All equipment installed shall be in accordance with design specifications.

II SYSTEMS AND EQUIPMENT TO BE TESTED
A. Static Uninterruptible Power Supply UPS
   1. UPS-Tunnel – three phase (50 kVA) / located in Electrical Rm. N5-SP21, Platform Level, Sector A
   2. UPS-Station – three phase (50 kVA) / located in Electrical Rm. N5-5B3-22, Basement Level 3, Sector A

III PARTICIPANTS
A. Owner’s witness
B. Electrical Contractor
C. Equipment Supplier

IV PERFORMANCE REQUIREMENTS
A. UPS shall supply full rated current under the following conditions or combinations thereof:
   1. Inverter switched to battery source
   2. Input voltages up to ± 10% from nominal
   3. Input frequency up to ± 5% from nominal
   4. THD of input voltage is 15% or more with a minimum crest factor of 3.0 and the largest single harmonic component is a minimum of 5% of the fundamental value.
   5. Load is 50% unbalanced continuously.
   6. When battery is sole energy source, at full-load and 80% power factor, the unit operates for 90 minutes.
   7. Output voltage remains within specified tolerance when input voltage varies between + 10% or minus 20% from nominal voltage.
   8. Maximum harmonic content of the output voltage waveform is 5% RMS total and 3% RMS for any single harmonic when applied to a totally non-linear full current load.
   9. Overload capacity of unit shall be 125% of full-load rating for 15 minutes without bypass source and 150% for 30 seconds under the same conditions.

V MONITORING
A. The communications module at the unit control panel shall provide the capability for the remote monitoring of the following via LON Mark compatible network interface units.
   1. Unit Status
   2. Unit Parameters
   3. Unit Alarms

B. Basic Battery Monitoring
   1. Battery Ground-Fault Detector to initiate visual and audible alarm when resistance to ground of either the positive or negative bus of the battery is less than 5000 ohms.
   2. Smoke/High Temperature detector shall initiate audible and visual alarm when either smoke or a temperature in excess of 167°F is sensed at the battery compartment.
   3. Sensing of cell and battery terminals via factory installed sensing leads.
   4. Battery voltage and ambient temperature
   5. Individual cell voltage, impedance, and temperature.
   6. Individual cell electrolyte levels
   7. Battery cycle warranty monitoring
VI  ELECTRICAL TESTS AND INSPECTIONS
A.  Factory representative to supervise installation, startup, preliminary and final testing.
B.  Verify and record physical and mechanical condition of the UPS through performance of the following inspections:
   1.  Confirm integrity of mechanical and electrical components.
   2.  Verify component type and labeling.
   3.  Verify ratings of installed components.
   4.  Confirm proper installation of mounting or anchorage devices
   5.  Verify battery mounting adequacy.
C.  Record the following Testing for the UPS unit.  Provide load bank (resistive and reactive) to simulate all load conditions up to the full-load of the unit.  Provide three-phase power meters to monitor parameters.
   1.  Test manual and automatic operation of the UPS system protective and alarm functions.
   2.  Test communication of status and alarms to the remote monitoring equipment.
   3.  Simulate via load bank the following:
      a.  Protective device operation.
      b.  Test duration of battery supply under normal source failure.  Unit shall carry full-load current for 90 minutes.
      c.  Test harmonic content of input and output at 25%, 50% and 100% of rated load.
      d.  Test output voltage under specified transient load conditions.
      e.  Test efficiency at 50%, 75% and 100% rated load.
      f.  Test battery monitoring system functions.
      g.  Test resistance to ground of battery negative pole.

VII  FUNCTIONAL PERFORMANCE TESTING
A.  Provide three-phase recording power meters to simultaneously monitor and record the following parameters at both the UPS and input terminals of a load served by the UPS.  Monitoring to extend over a 10 day period using actual intended loads following substantial completion.
   2.  Voltage:  Phase-to-phase, phase-to-neutral, phase-to-ground, and neutral-to-ground.
   3.  Frequency transients.
   4.  Voltage swells and sags.
   5.  Voltage impulses:  Phase-to-phase, phase-to-neutral, phase-to-ground and neutral-to-ground.
   6.  High frequency noise.
   7.  Radio-frequency interference.
   8.  THD for currents and voltages
   9.  Harmonic content of currents and voltages
   10.  Monitor and perform load and UPS power source switching.  Operate on generator power during a portion of the testing.

VIII  DOCUMENTATION AND ANALYSIS
A.  Documentation:  Record test points, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording.
B.  Analysis of Recorded Data and Report:  Review and analyze test observations and recorded data and submit a detailed written report.  Include the following:
   1.  Description of corrective actions performed during monitoring and subsequent results.
   2.  Recommendations for any additional actions to provide optimum performance.
   3.  Copies of monitoring summary graphics and graphics illustrating harmonic content.
   4.  Copies of graphics of power disturbance recordings that illustrate findings, conclusions and recommendations.
IX RESPONSIBILITIES
A. Coordinate with Construction Manager/Owner/Engineer regarding testing schedule and availability of equipment ready for testing.
B. Assure suitability for energization.

X TEST REPORTS
A. Provide three (3) copies of completed test reports.

Signatures: The undersigned have witnessed the above tests and verified that the tests were performed in accordance with Approved Commissioning Test Procedure and that the results recorded were the actual results observed/obtained.

Commissioning Coordinator: ........................................................................................................................................................

Installing Contractor: ...............................................................................................................................................................

Owner’s Witness: .................................................................................................................................................................

1.01 END OF EXAMPLE DESCRIPTION
### Visual Inspections

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<td>2</td>
<td>Components necessary for operation are installed</td>
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<td>3</td>
<td>All components labeled</td>
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<td>4</td>
<td>Ratings of installed components consistent with design documents</td>
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<td>Mounting and anchorage is satisfactory</td>
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<td>6</td>
<td>Grounding connections clean and tight</td>
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<td>7</td>
<td>Battery mounting is adequate</td>
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<td>8</td>
<td>Bypass equipment is installed</td>
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<td>Remote monitoring systems are installed and unit connected to this system</td>
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<tr>
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<td>Digital display is operational</td>
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<td>Indicating lights working properly</td>
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<td>All door and covers align and fit properly</td>
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<td>All hardware installed</td>
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<td>14</td>
<td>All cables properly installed, routed, and clear of energized parts</td>
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<td>Conductors and Terminal Blocks clearly labeled per wiring diagrams</td>
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<td>Interior free of moisture</td>
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<td>17</td>
<td>Mechanical interlocks free and operating properly</td>
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<td>18</td>
<td>Equipment is clean</td>
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<td>Check tightness of all accessible bolted connections w/ calibrated torque-wrench</td>
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<td>All batteries properly charged</td>
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<td>Installation manuals available and installed in protective pocket</td>
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"No" Responses
SECTION 26 08 00 – ATTACHMENT B

INSTALLATION VERIFICATION FORM

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Corrective Action

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<th>Date</th>
<th>Corrective Action</th>
<th>Completed By:</th>
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Signatures: The undersigned have performed the above installation check and verified that the installation is complies with the manufacturer’s and contract requirements.

Company / Print Name / Signature / Date

Installing Contractor: __________________________________________________________

Owner’s witness: ____________________________________________________________

END OF EXAMPLE INSTALLATION VERIFICATION FORM
SECTION 26 08 00 – ATTACHMENT C
EXAMPLE TEST PROCEDURE

I. OBJECTIVES
   A. Verify performance of Uninterruptible Power Supply (50 kVA) under normal and abnormal conditions.
   B. Reference Specification Section 26 33 53, Static Uninterruptible Power Supply

II. SYSTEMS AND EQUIPMENT TO BE TESTED
   A. UPS-TUNNEL – three phase 50 kVA / located in Electrical Rm. N5-5P21, Platform Level, Sector A
      1. Remote unit monitoring systems
      2. Local unit monitoring systems
      3. Battery monitoring systems
      4. Operator interface display

III. PREREQUISITES
   A. Final installation of this system. Y___ N___
   B. The following Test Procedures have been completed with acceptable results:
      1. 263353: UPS-TUNNEL start-up Y___ N___

IV. PARTICIPANTS
   A. Owner’s Witness
   B. Electrical Contractor
   C. Equipment Supplier’s Test Technician

V. TEST EQUIPMENT
   A. RPM (Reliable Power Measurements) meter(s)
   B. Load Bank supplying both resistive and reactive – 75 kVA minimum at 80% power factor

VI. PERFORMANCE REQUIREMENTS AND ELECTRICAL TESTS
   A. In accordance with general conditions of the contract, contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the performance of test. Stop the test and notify the owner if it is determined that any part of the test cannot be performed safely.
   B. Perform and document the following tests to assure all performance requirements for the unit have been met. Utilize recording meter(s) to record results.
C. UPS supplying full rated current via Load Bank under the following conditions:

1. Simulate Input voltages up to ± 10% from nominal. Operation satisfactory. Y___N___
2. Simulate Input frequency up to ± 5% from nominal. Operation satisfactory. Y___N___
3. Simulate THD of input voltage is 15% or more with a minimum crest factor of 3.0 and the largest single harmonic component is a minimum of 5% of the fundamental value. Y___N___
4. Simulate Load is 50% unbalanced continuously. Operation satisfactory. Y___N___
5. Output voltage remains within specified tolerance. Vary input voltage between plus 10% or minus 20% from nominal voltage. Operation satisfactory. Y___N___
6. Maximum harmonic content of the output voltage waveform is 5% RMS total and 3% RMS for a single harmonic when applied to a totally non-linear full current load. Y___N___
7. Overload unit to 125% of full-load rating for 15-minutes without bypass source. Operation satisfactory. Y___N___
8. Overload unit to 150% of full-load rating for 30-seconds without bypass source. Operation satisfactory. Y___N___
9. Test harmonic content of input and output at 25%, 50%, 75% and 100% of rated load and record. Utilize two (2) power recording meters. Y___N___
10. Test efficiency at 50%, 75% and 100% of rated load. Record efficiency. Y___N___
11. Test duration of battery supply under normal source failure conditions. Unit carries full rated load for a period of 90-minutes. Y___N___

VII. MONITORING PERFORMANCE TESTS

A. The communications module at the unit control panel shall provide the capability for the remote monitoring of the following LON Mark compatible network interface units

1. Unit Status is communicated to the Remote Monitoring Panel Y___N___
2. Unit Parameters are communicated to the Remote Monitoring Panel Y___N___
3. Unit Alarms are communicated to the Remote Monitoring Panel Y___N___
B. Basic Battery Monitoring

1. Simulate a resistance to ground of less than 5000 ohms on either the positive or negative terminal of a unit battery. Battery ground-fault detector initiates a visual and audible alarm and this alarm is communicated to Remote Monitoring Panel.  
   Y___N___

2. Simulate a High Temperature Alarm in the battery compartment by raising the temperature above 167°F using a hair dryer or similar device. Smoke/Heat detector initiates an audible and visual alarm and this alarm is communicated to the Remote Monitoring Panel  
   Y___N___

3. Inject Smoke into the battery compartment. Smoke/Heat detector initiates an audible and visual alarm and this alarm is communicated to the Remote Monitoring Panel.  
   Y___N___

4. Battery voltage is displayed at Control Display  
   Y___N___

5. Battery ambient temperature is displayed at Control Display  
   Y___N___

6. Individual sensing of cell and battery terminals is displayed at the Control Display via factory installed sensing leads.  
   Y___N___

7. Individual cell voltages are displayed at Control Display  
   Y___N___

8. Individual cell impedances are displayed at Control Display  
   Y___N___

9. Individual cell temperatures are displayed at Control Display  
   Y___N___

10. Individual cell electrolyte levels are displayed at Control Display  
    Y___N___

11. Battery cycle warranty monitoring is Displayed at Control Display  
    Y___N___
VIII. FUNCTIONAL PERFORMANCE TESTS

A. Provide three-phase recording power meters to simultaneously monitor and record the following parameters at both the UPS and input terminals of a load served by the UPS.

B. Monitoring to extend over a 10-day period using actual intended loads following substantial completion.
   1. Current: Phase, neutral and ground conductor. Y___N___
   2. Voltage: Phase-to-neutral, phase-to-ground, neutral-to-ground. Y___N___
   3. Frequency Transients. Y___N___
   4. Voltage Swells and Sags. Y___N___
   5. Voltage Impulses: Phase-to-neutral, phase-to-ground and neutral-to-ground. Y___N___
   6. High frequency noise. Y___N___
   7. Radio frequency noise. Y___N___
   8. THD for currents and voltage. Y___N___
   9. Harmonic content of currents and voltage. Y___N___

IX. TEST RESULTS

A. Documentation: Record test points, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording.

B. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following
   1. Description of corrective actions performed during monitoring and subsequent results.
   2. Recommendations for any additional actions to provide optimum performance.
   3. Copies of monitoring summary graphics and graphics illustrating harmonic content.
   4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions and recommendations.

X. RESPONSIBILITIES

A. Coordinate with Construction Manager/Owner/Engineer regarding testing schedule and availability of equipment ready for testing.

B. Assure suitability for energization.

XI. TEST REPORTS
A. Provide three (3) copies of completed test reports.

Issues Noted? Yes____ No____

Issue Report Numbers:__________________________________________________________

Notes:

Signatures: The undersigned have witnessed the above test and verified that the test was performed in accordance with the Approved Commissioning Test Procedure and that the results recorded were the actual results observed.

Company / Print Name / Signature / Date

Installing Contractor: ____________________________________________________________

Owner’s witness: ________________________________________________________________

END OF EXAMPLE TEST PROCEDURE
### TABLE 26 08 00 – D1

**SWITCHGEAR INSULATION-RESISTANCE TEST VOLTAGE**

<table>
<thead>
<tr>
<th>Voltage Rating</th>
<th>Minimum dc Test Voltage</th>
<th>Recommended Minimum Insulation Resistance In Megohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 250</td>
<td>500</td>
<td>50</td>
</tr>
<tr>
<td>251 - 600</td>
<td>1,000</td>
<td>100</td>
</tr>
<tr>
<td>601 - 5,000</td>
<td>2,500</td>
<td>1,000</td>
</tr>
<tr>
<td>5,001 - 15,000</td>
<td>2,500</td>
<td>5,000</td>
</tr>
<tr>
<td>15,001 - 25,000</td>
<td>5,000</td>
<td>20,000</td>
</tr>
</tbody>
</table>

In the absence of consensus standards dealing with insulation-resistance tests, the NETA Technical Committee suggests the above representative values.

### TABLE 26 08 00 – D2

**SWITCHGEAR LOW-FREQUENCY WITHSTAND TEST VOLTAGES**

<table>
<thead>
<tr>
<th>Type of Switchgear</th>
<th>Rated kV</th>
<th>Maximum Test Voltage kV</th>
<th>ac</th>
<th>dc</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC (Metal-Clad Switchgear)</td>
<td>4.76</td>
<td>14.0</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.25</td>
<td>27.0</td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>27.0</td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td>SC (Station-Type Cubicle Switchgear)</td>
<td>15.5</td>
<td>37.0</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>38.0</td>
<td>60.0</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>72.5</td>
<td>120.0</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>MEI (Metal-Enclosed Interrupter Switchgear)</td>
<td>4.76</td>
<td>14.0</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.25</td>
<td>19.0</td>
<td>27.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>27.0</td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.5</td>
<td>37.0</td>
<td>52.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.8</td>
<td>45.0</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>38.0</td>
<td>60.0</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
Derived from ANSI/IEEE C37.20.2-1987, Paragraph 5.5, Metal-Clad and Station-Type Cubicle Switchgear and C37.20.3-1987, Paragraph 5.5, Metal-Enclosed Interrupter Switchgear, and includes 0.75 multiplier with fraction rounded down. The column headed "DC Withstand" is given as a reference only for those using dc tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand Test Parameters specified for voltage rating of switchgear. The presence of this column in no way implies any requirement for a dc withstand test on ac equipment or that a dc withstand test represents an acceptable alternative to the low-frequency withstand tests specified in this specification, either for design tests, production tests, conformance tests, or field tests. When making dc tests, the voltage shall be raised to the test value in discrete steps and held for a period of one minute. Because of the variable voltage distribution encountered when making dc withstand tests, the manufacturer shall be contacted for recommendations before applying dc withstand tests to the switchgear. Voltage transformers above 34.5 kV shall be disconnected when testing with dc. Refer to ANSI/IEEE C57-13-1978 (IEEE Standard Requirements for Instrument Transformers) (R 1986) [10], Section 8 and, in particular 8.8.2, (the last paragraph) which reads "Periodic kenotron tests shall not be applied to transformers of higher than 34.5 kV voltage rating." Consult Manufacturer

**TABLE 26 08 00 - D3**

**RECOMMENDED DISSIPATION FACTOR/POWER FACTOR OF LIQUID-FILLED TRANSFORMER**

<table>
<thead>
<tr>
<th></th>
<th>Oil Maximum</th>
<th>Silicone Maximum</th>
<th>Tetra-chloroethylene Maximum</th>
<th>High Fire Point Hydrocarbon Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Power Transformers</td>
<td>0.5%</td>
<td>0.5%</td>
<td>3.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>New Distribution Transformers</td>
<td>1.0%</td>
<td>1.0%</td>
<td>3.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Remanufactured Power Transformers</td>
<td>1.0%</td>
<td>1.0%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Remanufactured Distribution Transformers</td>
<td>1.5%</td>
<td>1.5%</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

In the absence of consensus standards dealing with transformer dissipation factor/power factor values, the NETA Technical Committee suggests the above representative values.
## TEST LIMITS FOR NEW INSULATING OIL RECEIVED IN NEW EQUIPMENT

<table>
<thead>
<tr>
<th>Test</th>
<th>ASTM Method</th>
<th>69 kV and Below</th>
<th>Above 69 kV through 230 kV</th>
<th>345 Class kV and Above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric breakdown, kV minimum</td>
<td>D877</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Dielectric breakdown, kV minimum @ 0.04 gap</td>
<td>D1816</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Dielectric breakdown, kV minimum @ 0.08 gap</td>
<td>D1816</td>
<td>40</td>
<td>48</td>
<td>60</td>
</tr>
<tr>
<td>Interfacial tension mM/m minimum</td>
<td>D971</td>
<td>35</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Neutralization number, mg KOH/g maximum</td>
<td>D974</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Water content, ppm maximum</td>
<td>D1533</td>
<td>25</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Power factor at 25°C, %</td>
<td>D924</td>
<td>0.15</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>Power factor at 100°C, %</td>
<td>D924</td>
<td>1.50</td>
<td>1.00</td>
<td>0.30</td>
</tr>
<tr>
<td>Color</td>
<td>D1500</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Visual Condition</td>
<td>D1524</td>
<td>Bright &amp; Clear</td>
<td>Bright &amp; Clear</td>
<td>Bright &amp; Clear</td>
</tr>
</tbody>
</table>

1 IEEE C57.106-1991 (Guide for Acceptance and Maintenance of Insulating Oil in Equipment), Tables 1, 2, and 3.

## TEST LIMITS FOR SILICON INSULATING LIQUID IN NEW TRANSFORMERS

<table>
<thead>
<tr>
<th>Test</th>
<th>ASTM Method</th>
<th>Acceptable Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric Breakdown, kV minimum</td>
<td>D877</td>
<td>30</td>
</tr>
<tr>
<td>Visual</td>
<td>D2129</td>
<td>clear, free of particles</td>
</tr>
<tr>
<td>Water Content, ppm maximum</td>
<td>D1533</td>
<td>50</td>
</tr>
<tr>
<td>Dissipation factor, % max. @ 25°C</td>
<td>D924</td>
<td>0.1</td>
</tr>
<tr>
<td>Viscosity, cSt @ 25°C</td>
<td>D445</td>
<td>47.5 - 52.5</td>
</tr>
<tr>
<td>Fire Point, °C, minimum</td>
<td>D92</td>
<td>340</td>
</tr>
<tr>
<td>Neutralization number, mg KOH/g max.</td>
<td>D974</td>
<td>0.01</td>
</tr>
</tbody>
</table>
### Table 26 08 00 – D4 (CONTINUED)

#### TYPICAL VALUES FOR LESS FLAMMABLE HYDROCARBON

**INSULATING LIQUID RECEIVED IN NEW EQUIPMENT**

<table>
<thead>
<tr>
<th>Test</th>
<th>ASTM Method</th>
<th>Less Flammable Hydrocarbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric Breakdown, kV minimum 0.04 gap</td>
<td>D1816</td>
<td>20</td>
</tr>
<tr>
<td>Desirable</td>
<td>D1816</td>
<td>30</td>
</tr>
<tr>
<td>Dielectric Breakdown, kV minimum 0.08 gap</td>
<td>D1816</td>
<td>40</td>
</tr>
<tr>
<td>Above 34.5 kV Class</td>
<td>D1816</td>
<td>50</td>
</tr>
<tr>
<td>Desirable</td>
<td>D1816</td>
<td>60</td>
</tr>
<tr>
<td>Dielectric Breakdown, kV minimum</td>
<td>D877</td>
<td>30</td>
</tr>
<tr>
<td>Visual</td>
<td>D1524</td>
<td>Clear</td>
</tr>
<tr>
<td>Water Content, ppm maximum</td>
<td>D1533B</td>
<td>25</td>
</tr>
<tr>
<td>Dissipation factor, % maximum @ 25°C</td>
<td>D924</td>
<td>0.1</td>
</tr>
<tr>
<td>Dissipation factor, % maximum @ 100°C</td>
<td>D924</td>
<td>1.0</td>
</tr>
<tr>
<td>Fire Point (°C) minimum</td>
<td>D92</td>
<td>300</td>
</tr>
<tr>
<td>Flash Point (°C) Typical</td>
<td>D92</td>
<td>270-290</td>
</tr>
<tr>
<td>Neutralization number, mg KOH/g maximum</td>
<td>D974 or D664</td>
<td>0.03</td>
</tr>
<tr>
<td>Interfacial Tension, mN/m minimum @ 25°C</td>
<td>D971</td>
<td>38</td>
</tr>
</tbody>
</table>


### TABLE 26 08 00 – D5

#### TRANSFORMER INSULATION-RESISTANCE

**ACCEPTANCE TEST VOLTAGE AND MINIMUM RESULTS**

<table>
<thead>
<tr>
<th>Transformer Coil Rating Type in Volts</th>
<th>Minimum dc Test Voltage</th>
<th>Recommended Minimum Insulation Resistance in Megohms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Liquid Filled</td>
</tr>
<tr>
<td>0 - 600</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>601 - 500</td>
<td>2500</td>
<td>1000</td>
</tr>
<tr>
<td>5001 – 15000</td>
<td>5000</td>
<td>5000</td>
</tr>
</tbody>
</table>
## TABLE 26 08 00 – D6

### MEDIUM VOLTAGE CABLES

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>Rated Cable Voltage</th>
<th>Insulation Level</th>
<th>Test Voltage kV, dc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastomeric: Butyl and Oil Base</td>
<td>5 kV</td>
<td>100%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>5 kV</td>
<td>133%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>15 kV</td>
<td>100%</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>15 kV</td>
<td>133%</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>25 kV</td>
<td>100%</td>
<td>80</td>
</tr>
<tr>
<td>Elastomeric: EPR</td>
<td>5 kV</td>
<td>100%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>5 kV</td>
<td>133%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>8 kV</td>
<td>100%</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>8 kV</td>
<td>133%</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>15 kV</td>
<td>100%</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>15 kV</td>
<td>133%</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>25 kV</td>
<td>100%</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>25 kV</td>
<td>133%</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>28 kV</td>
<td>100%</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>35 kV</td>
<td>100%</td>
<td>100</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>5 kV</td>
<td>100%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>5 kV</td>
<td>133%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>8 kV</td>
<td>100%</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>8 kV</td>
<td>133%</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>15 kV</td>
<td>100%</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>15 kV</td>
<td>133%</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>25 kV</td>
<td>100%</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>25 kV</td>
<td>133%</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>35 kV</td>
<td>100%</td>
<td>100</td>
</tr>
</tbody>
</table>

Derived from ANSI/IEEE Standard 141-1993 Table 12-9 and by factoring the applicable ICEA/NEMA Standards.

**NOTE:** AEIC CS5 and CS6, and ANSI/IEEE Standard 400 do not differentiate cables based upon insulation thickness and, consequently, list differing test voltages.
<table>
<thead>
<tr>
<th>Range of Rated Continuous Current Amperes</th>
<th>Maximum Trip Time in Seconds For Each Maximum Frame Rating&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 250V</td>
</tr>
<tr>
<td>0-30</td>
<td>50</td>
</tr>
<tr>
<td>31-50</td>
<td>80</td>
</tr>
<tr>
<td>51-100</td>
<td>140</td>
</tr>
<tr>
<td>101-150</td>
<td>200</td>
</tr>
<tr>
<td>151-225</td>
<td>230</td>
</tr>
<tr>
<td>226-400</td>
<td>300</td>
</tr>
<tr>
<td>401-600</td>
<td>---------</td>
</tr>
<tr>
<td>601-800</td>
<td>---------</td>
</tr>
<tr>
<td>801-1000</td>
<td>---------</td>
</tr>
<tr>
<td>1001-1200</td>
<td>---------</td>
</tr>
<tr>
<td>1201-1600</td>
<td>---------</td>
</tr>
<tr>
<td>1601-2000</td>
<td>---------</td>
</tr>
<tr>
<td>2001-2500</td>
<td>---------</td>
</tr>
<tr>
<td>2501-5000</td>
<td>---------</td>
</tr>
</tbody>
</table>

Reproduction of Table 5-3 from NEMA Standard AB4-1991.

<sup>1</sup> For integrally-fused circuit breakers, trip times may be substantially longer if tested with the fuses replaced by solid links (shorting bars).
TABLE 26 08 00 – D8
INSTANTANEOUS TRIP SETTING TOLERANCES FOR
FIELD TESTING OF MARKED ADJUSTABLE TRIP CIRCUIT BREAKERS

<table>
<thead>
<tr>
<th>Ampere Rating</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤250</td>
<td>+40%</td>
<td>+40%</td>
</tr>
<tr>
<td></td>
<td>-25%</td>
<td>-30%</td>
</tr>
<tr>
<td>&gt;250</td>
<td>±25%</td>
<td>±30%</td>
</tr>
</tbody>
</table>

Reproduction of Table 5-4 from NEMA publication AB4-1991.

For circuit breakers with nonadjustable instantaneous trips, tolerances apply to the manufacturer's published trip range, i.e., +40 percent on high side, -30 percent on low side.
### TABLE 26 08 00 – D9

**INSTRUMENT TRANSFORMER DIELECTRIC TESTS FIELD ACCEPTANCE**

<table>
<thead>
<tr>
<th>Nominal System (kV)</th>
<th>BIL (kV)</th>
<th>Field Test Voltage (kV)</th>
<th>ac</th>
<th>dc(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>10</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>30</td>
<td>7.5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>45</td>
<td>11.25</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>60</td>
<td>14.25</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>8.32</td>
<td>75</td>
<td>19.5</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>13.8</td>
<td>95</td>
<td>25.5</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>13.8</td>
<td>110</td>
<td>25.5</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>125</td>
<td>30</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>150</td>
<td>37.5</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>34.5</td>
<td>150</td>
<td>37.5</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>34.5</td>
<td>200</td>
<td>52.5</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>250</td>
<td>71.25</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>350</td>
<td>105</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>450</td>
<td>138.75</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>550</td>
<td>172.50</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>138</td>
<td>550</td>
<td>172.50</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>138</td>
<td>650</td>
<td>206.25</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>161</td>
<td>650</td>
<td>206.25</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>161</td>
<td>750</td>
<td>243.75</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>900</td>
<td>296.25</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>1050</td>
<td>345</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>345</td>
<td>1300</td>
<td>431.25</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>1675</td>
<td>562.5</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>1800</td>
<td>600</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>765</td>
<td>2050</td>
<td>690</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Derived from Paragraph 8.8.2 and Tables 2 and 7 of ANSI/IEEE C57.13-1993 (Standard Requirements for Instrument Transformers).

\(^1\) DC potential tests are not recommended for transformers rated higher than 200 kV BIL. DC tests may prove beneficial as a reference for future testing. In such cases the test direct voltage shall not exceed the original factory test RMS alternating voltages.
### TABLE 26 08 00 – D10

**MAXIMUM ALLOWABLE VIBRATION AMPLITUDE**

<table>
<thead>
<tr>
<th>Speed - RPM</th>
<th>Amplitude - Inches Peak to Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000 and above</td>
<td>0.001</td>
</tr>
<tr>
<td>1500 - 2999</td>
<td>0.002</td>
</tr>
<tr>
<td>1000 - 1499</td>
<td>0.0025</td>
</tr>
<tr>
<td>999 and below</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Derived from NEMA publication MG 1-1987, Sections 20.53, 21.54, 22.54, 23.52, and 24.50.

### TABLE 26 08 00 – D11

**OVERPOTENTIAL TEST VOLTAGES FOR ELECTRICAL APPARATUS OTHER THAN INDUCTIVE EQUIPMENT**

<table>
<thead>
<tr>
<th>Nominal System (Line) Voltage (kV)</th>
<th>Insulation Class</th>
<th>AC Factory Test (kV)</th>
<th>Maximum Field Applied AC Test (kV)</th>
<th>Maximum Field Applied DC Test (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>1.2</td>
<td>10</td>
<td>6.0</td>
<td>8.5</td>
</tr>
<tr>
<td>2.4</td>
<td>2.5</td>
<td>15</td>
<td>9.0</td>
<td>12.7</td>
</tr>
<tr>
<td>4.8</td>
<td>5.0</td>
<td>19</td>
<td>11.4</td>
<td>16.1</td>
</tr>
<tr>
<td>8.3</td>
<td>8.7</td>
<td>26</td>
<td>15.6</td>
<td>22.1</td>
</tr>
<tr>
<td>14.4</td>
<td>15.0</td>
<td>34</td>
<td>20.4</td>
<td>28.8</td>
</tr>
<tr>
<td>18.0</td>
<td>18.0</td>
<td>40</td>
<td>24.0</td>
<td>33.9</td>
</tr>
<tr>
<td>25.0</td>
<td>25.0</td>
<td>50</td>
<td>30.0</td>
<td>42.4</td>
</tr>
<tr>
<td>34.5</td>
<td>35.0</td>
<td>70</td>
<td>42.0</td>
<td>59.4</td>
</tr>
<tr>
<td>46.0</td>
<td>46.0</td>
<td>95</td>
<td>57.0</td>
<td>80.6</td>
</tr>
<tr>
<td>69.0</td>
<td>69.0</td>
<td>140</td>
<td>84.0</td>
<td>118.8</td>
</tr>
</tbody>
</table>

In the absence of consensus standards, the NETA Technical Committee suggests the above representative values.

1 Intermediate voltage ratings are placed in the next higher insulation class.
### US Standard Bolt Torques for Bus Connections

**Heat-Treated Steel - Cadmium or Zinc Plated**

<table>
<thead>
<tr>
<th>Grade</th>
<th>SAE 1 &amp; 2</th>
<th>SAE 5</th>
<th>SAE 7</th>
<th>SAE 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Tensile (P.S.I.)</td>
<td>64K</td>
<td>105K</td>
<td>133K</td>
<td>150K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bolt Diameter in Inches</th>
<th>Torque (Foot Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>4.0 5.6 8.0 8.4</td>
</tr>
<tr>
<td>5/16</td>
<td>7.2 11.2 15.2 17.6</td>
</tr>
<tr>
<td>3/8</td>
<td>12.0 20.0 27.2 29.6</td>
</tr>
<tr>
<td>7/16</td>
<td>19.2 32.0 44.0 48.0</td>
</tr>
<tr>
<td>1/2</td>
<td>29.6 48.0 68.0 73.6</td>
</tr>
<tr>
<td>9/16</td>
<td>42.4 70.4 96.0 105.6</td>
</tr>
<tr>
<td>5/8</td>
<td>59.2 96.0 133.6 144.0</td>
</tr>
<tr>
<td>3/4</td>
<td>96.0 160.0 224.0 236.8</td>
</tr>
<tr>
<td>7/8</td>
<td>152.0 241.6 352.0 378.4</td>
</tr>
<tr>
<td>1.0</td>
<td>225.6 372.8 528.0 571.2</td>
</tr>
</tbody>
</table>

### Bolt Torques for Bus Connections

**Silicon Bronze Fasteners**

**Torque (Foot-Pounds)**

<table>
<thead>
<tr>
<th>Bolt Diameter in Inches</th>
<th>Nonlubricated</th>
<th>Lubricated</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>3/8</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>1/2</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>5/8</td>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>3/4</td>
<td>70</td>
<td>60</td>
</tr>
</tbody>
</table>

1 Bronze alloy bolts shall have a minimum tensile strength of 70,000 pounds per square inch.
### TABLE 26 08 00 – D12 (CONTINUED)
#### ALUMINUM ALLOY FASTENERS

<table>
<thead>
<tr>
<th>Bolt Diameter in Inches</th>
<th>Lubricated</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16</td>
<td>8.0</td>
</tr>
<tr>
<td>3/8</td>
<td>11.2</td>
</tr>
<tr>
<td>½</td>
<td>20.0</td>
</tr>
<tr>
<td>5/8</td>
<td>32.0</td>
</tr>
<tr>
<td>¾</td>
<td>48.0</td>
</tr>
</tbody>
</table>

2 Aluminum alloy bolts shall have a minimum tensile strength of 55,000 pounds per square inch.

### BOLT TORQUES FOR BUS CONNECTIONS
#### STAINLESS STEEL FASTENERS

<table>
<thead>
<tr>
<th>Bolt Diameter in Inches</th>
<th>Uncoated</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16</td>
<td>14</td>
</tr>
<tr>
<td>3/8</td>
<td>25</td>
</tr>
<tr>
<td>½</td>
<td>45</td>
</tr>
<tr>
<td>5/8</td>
<td>60</td>
</tr>
<tr>
<td>3/4</td>
<td>90</td>
</tr>
</tbody>
</table>

3 Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy.

Belleville washers: 302 alloy.
### TABLE 26 08 00 – D13

**INSULATION RESISTANCE TESTS ON ELECTRICAL APPARATUS AND SYSTEMS**

<table>
<thead>
<tr>
<th>Maximum Rating of Equipment in Volts</th>
<th>Minimum Test Voltage, dc in Volts</th>
<th>Recommended Minimum Insulation Resistance in Megohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>500</td>
<td>25</td>
</tr>
<tr>
<td>600</td>
<td>1,000</td>
<td>100</td>
</tr>
<tr>
<td>5,000</td>
<td>2,500</td>
<td>1,000</td>
</tr>
<tr>
<td>8,000</td>
<td>2,500</td>
<td>2,000</td>
</tr>
<tr>
<td>15,000</td>
<td>2,500</td>
<td>5,000</td>
</tr>
<tr>
<td>25,000</td>
<td>5,000</td>
<td>20,000</td>
</tr>
<tr>
<td>35,000</td>
<td>15,000</td>
<td>100,000</td>
</tr>
<tr>
<td>46,000</td>
<td>15,000</td>
<td>100,000</td>
</tr>
<tr>
<td>69,000</td>
<td>15,000</td>
<td>100,000</td>
</tr>
</tbody>
</table>

In the absence of consensus standards dealing with insulation-resistance tests, the NETA Technical Committee suggests the above representative values.

See Table 2600.14 for temperature correction factors.
### TABLE 26 08 00 - D14

**INSULATION RESISTANCE CONVERSION FACTORS**

FOR CONVERSION OF TEST TEMPERATURE TO 20°C

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>°F</th>
<th>Apparatus Containing Immersed Oil Insulations</th>
<th>Apparatus Containing Solid Insulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>0.25</td>
<td>0.40</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>0.36</td>
<td>0.45</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>20</td>
<td>68</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>25</td>
<td>77</td>
<td>1.40</td>
<td>1.30</td>
</tr>
<tr>
<td>30</td>
<td>86</td>
<td>1.98</td>
<td>1.60</td>
</tr>
<tr>
<td>35</td>
<td>95</td>
<td>2.80</td>
<td>2.05</td>
</tr>
<tr>
<td>40</td>
<td>104</td>
<td>3.95</td>
<td>2.50</td>
</tr>
<tr>
<td>45</td>
<td>113</td>
<td>5.60</td>
<td>3.25</td>
</tr>
<tr>
<td>50</td>
<td>122</td>
<td>7.85</td>
<td>4.00</td>
</tr>
<tr>
<td>55</td>
<td>131</td>
<td>11.20</td>
<td>5.20</td>
</tr>
<tr>
<td>60</td>
<td>140</td>
<td>15.85</td>
<td>6.40</td>
</tr>
<tr>
<td>65</td>
<td>149</td>
<td>22.40</td>
<td>8.70</td>
</tr>
<tr>
<td>70</td>
<td>158</td>
<td>31.75</td>
<td>10.00</td>
</tr>
<tr>
<td>75</td>
<td>167</td>
<td>44.70</td>
<td>13.00</td>
</tr>
<tr>
<td>80</td>
<td>176</td>
<td>63.50</td>
<td>16.00</td>
</tr>
</tbody>
</table>
### IEEE 519-1992 STANDARDS

#### Voltage Distortion Limits

<table>
<thead>
<tr>
<th>Bus Voltage at PCC*</th>
<th>Individual Voltage Distortion (%)</th>
<th>Total Voltage Distortion THD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69 kV and Below</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>69.001 kV through 161 kV</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>161.001 kV and Above</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**NOTE:** High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

*PCC is Point of Common Coupling.

#### Current Distortion Limits for General Distribution Systems

(120 V Through 69 000 V)

<table>
<thead>
<tr>
<th>Individual Harmonic Order (Odd Harmonics)</th>
<th>Maximum Harmonic Current Distortion In Percent of $I_L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{sc}/I_L$</td>
<td>(&lt;11)</td>
</tr>
<tr>
<td>(&lt;20)*</td>
<td>4.0</td>
</tr>
<tr>
<td>(20 &lt; 50)</td>
<td>7.0</td>
</tr>
<tr>
<td>(50 &lt; 100)</td>
<td>10.0</td>
</tr>
<tr>
<td>(100 &lt; 1000)</td>
<td>12.0</td>
</tr>
<tr>
<td>(&gt;1000)</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Even harmonics are limited to 25% of the odd harmonic limits above.

Current Distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

*All power generation equipment is limited to these values of current distortion, regardless of actual $I_{sc}/I_L$.

where $I_{sc}$ = maximum short-circuit current at PCC*.

$I_L$ = maximum demand load current (fundamental frequency component) at PCC*.

**PCC is Point of Common Coupling.
### TABLE 26 08 00 - D16
TRANSFORMER ANSI AND NEMA SOUND LEVELS

#### Distribution Transformer Sound Levels

<table>
<thead>
<tr>
<th>Transformer Capacity</th>
<th>Maximum Sound Level (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 kVA</td>
<td>30</td>
</tr>
<tr>
<td>6-25 kVA</td>
<td>40</td>
</tr>
<tr>
<td>26 to 150 kVA</td>
<td>42</td>
</tr>
<tr>
<td>151 to 225 kVA</td>
<td>43</td>
</tr>
<tr>
<td>226 to 300 kVA</td>
<td>47</td>
</tr>
<tr>
<td>301 to 500 kVA</td>
<td>51</td>
</tr>
</tbody>
</table>

#### Ultra-quiet Isolation Transformer Sound Levels

<table>
<thead>
<tr>
<th>Transformer Capacity</th>
<th>Maximum Sound Level (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 500 kVA</td>
<td>40</td>
</tr>
</tbody>
</table>

#### Isolation Transformer Sound Levels

<table>
<thead>
<tr>
<th>Transformer Capacity</th>
<th>Maximum Sound Level (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 9 kVA</td>
<td>40</td>
</tr>
<tr>
<td>10 to 50 kVA</td>
<td>45</td>
</tr>
<tr>
<td>51 to 150 kVA</td>
<td>50</td>
</tr>
<tr>
<td>151 to 300 kVA</td>
<td>55</td>
</tr>
<tr>
<td>301 to 500 kVA</td>
<td>60</td>
</tr>
<tr>
<td>501 to 700 kVA</td>
<td>62</td>
</tr>
<tr>
<td>701 to 1000 kVA</td>
<td>64</td>
</tr>
<tr>
<td>1001 to 1500 kVA</td>
<td>65</td>
</tr>
</tbody>
</table>

#### Substation Transformer Sound Levels

Sound levels not to exceed NEMA TR-1
### TABLE 26 08 00 - D17

**NEMA INSULATION CLASS TEMPERATURE TABLE**

<table>
<thead>
<tr>
<th>Temperature Tolerance Class</th>
<th>Maximum Operation Temperature Allowed</th>
<th>Allowable Temperature Rise at Full Load 1.0 service factor motor</th>
<th>Allowable Temperature Rise 1.15 service factor motor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td>°F</td>
<td>°C</td>
</tr>
<tr>
<td>A</td>
<td>105</td>
<td>221</td>
<td>60</td>
</tr>
<tr>
<td>B</td>
<td>130</td>
<td>266</td>
<td>80</td>
</tr>
<tr>
<td>F</td>
<td>155</td>
<td>311</td>
<td>105</td>
</tr>
<tr>
<td>H</td>
<td>180</td>
<td>356</td>
<td>125</td>
</tr>
</tbody>
</table>

\[ T(°F) = \left[ T(°C) \right] \left( \frac{9}{5} \right) + 32 \]

¹ Allowable temperature rises are based upon a reference ambient temperature of 40°C. Operation temperature is reference temperature + allowable temperature rise + allowance for “hot spot” winding.

**Example Temperature Tolerance Class F**

40°C + 105°C + 10°C = 155°C Maximum

In general a motor should not operate with temperatures above the maximum. Each 10°C rise above the rating may reduce the motor lifetime by one half.
## TABLE 26 08 00 - D18

SOUND TRANSIT ILLUMINANCE LEVEL CRITERIA

<table>
<thead>
<tr>
<th>AREA</th>
<th>Illuminance/Average Horizontal Footcandles</th>
<th>AREA</th>
<th>Illuminance/Average Horizontal Footcandles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Platforms</td>
<td>15</td>
<td>Mezzanines</td>
<td>15</td>
</tr>
<tr>
<td>Stair, Elevator Cabs, Escalators</td>
<td>15</td>
<td>Outdoor Entrances to Elevators, Escalators, Stairways</td>
<td>15</td>
</tr>
<tr>
<td>Farevending Areas</td>
<td>20</td>
<td>Emergency Exit Lighting per Code</td>
<td>1 / minimum</td>
</tr>
<tr>
<td>Public Restrooms</td>
<td>30</td>
<td>Concessions</td>
<td>15</td>
</tr>
<tr>
<td>Entry approaches to Stations</td>
<td>10</td>
<td>Covered Bicycle Parking</td>
<td>10</td>
</tr>
<tr>
<td>Uncovered Bicycle Parking</td>
<td>5</td>
<td>Open Plaza</td>
<td>5</td>
</tr>
<tr>
<td>Pedestrian Walkways (adjacent to roadways)</td>
<td>5</td>
<td>Passenger Drop-off</td>
<td>5</td>
</tr>
<tr>
<td>Bus Loading and Roadways</td>
<td>5</td>
<td>Open Parking Lots</td>
<td>1 / minimum</td>
</tr>
<tr>
<td>Face of Signs</td>
<td>10</td>
<td>Covered Parking</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AREA</th>
<th>Illuminance/Average Horizontal Footcandles</th>
<th>AREA</th>
<th>Illuminance/Average Horizontal Footcandles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical, Electrical and Communications Rooms</td>
<td>20</td>
<td>Storage, Custodial Rooms, Toilets, &amp; Staff Restrooms</td>
<td>20</td>
</tr>
<tr>
<td>Staff Rooms</td>
<td>50</td>
<td>Elevator Machine Rooms</td>
<td>20</td>
</tr>
<tr>
<td>Systems Rooms</td>
<td>20</td>
<td>Office</td>
<td>75</td>
</tr>
<tr>
<td>Shop Area</td>
<td>50</td>
<td>Pit Area</td>
<td>100</td>
</tr>
<tr>
<td>Yard with Tracks</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 26 08 00 – ATTACHMENT D

TEST PARAMETER TABLES

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 PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for the furnishing, installing, and testing, including all wire, cable and mounting of the Double ended unit substation. The double ended unit substation includes:

1. Medium voltage cable connection to transformer from top.
2. Medium voltage dry-type transformer.
3. Switchgear section, main – tie – main arrangement between two close coupled transformers

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 26 05 25, Wire and Cable
2. Section 26 05 26, Grounding and Bonding for Electrical Systems
3. Section 26 05 53, Identification for Electrical Systems
4. Section 26 08 00, Commissioning of Electrical Systems

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American National Standards Institute (ANSI):

   a. ANSI/NEMA 7.2.1 Maintenance Testing Specifications for Dry-Type Transformers: Air-Cooled, 600 Volts and Below - Small (167 kV Single-Phase, 500 kVA Three-Phase, and Smaller) and Air-Cooled, All Above 600 Volts and 600 Volts and Below - Large (Greater than 167 kV Single-Phase and 500 kVA Three-Phase)

   b. ANSI/IEEE C37.13.1 Definite Purpose Switching Devices for Use in Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

   c. ANSI C37.16 Low Voltage Power Circuit Breakers and AC Power Circuit Protectors

   d. ANSI/IEEE C37.35 Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Interrupter Switches

   e. ANSI C37.17 Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers
f. ANSI/IEEE C37.30 Standard Requirements for High Voltage Switches  
g. ANSI C37.50 Switchgear - Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures  
h. ANSI C37.121 Switchgear - Unit Substations - Requirements  
i. ANSI/IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers  
j. ANSI/IEEE C57.13 Standard Requirements for Instrument Transformers  
k. ANSI/IEEE C57.12.01 Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin Encapsulated Windings  
l. ANSI C57.12.50 Distribution Transformers 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase with High-Voltage 601-34 500 Volts, Low Voltage 120-600 Volt, Ventilated Dry-Type  
m. ANSI C57.12.51 Dry-Type Power Transformers 501 kVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts, Requirements for Ventilated  
n. ANSI/IEEE 344 Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations  

   a. ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus  
   b. ASTM D522 Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings  
   d. ASTM D3363 Standard Test Method for Film Hardness by Pencil Test  

3. Institute of Electrical and Electronics Engineers (IEEE):  
   a. IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers  

1.03 Submittals:  

A. Working Drawings: Submit working drawings including a coordinated unit substation set of plans, elevations, and details showing all section alignments and connections between sections.  

B. Coordination Drawing: Submit unit substation dimensioned plans, elevations, sections, including required clearances and service space around equipment for each substation section. Ensure that the drawings of switchgear front and plan layout and relationships between components and adjacent structural and mechanical elements. Also show on the drawings, support locations, type of support, and weight on each support. Include shipping sections to ensure they will not pose any problem of bring in and out of the electrical room thru equipment hatch shown in the floor plan of the electrical room.
C. Manufacturer Seismic Qualification Certification: Submit certification that unit substation sections, accessories, and components will withstand seismic forces as defined in the building code applicable to the site and of Contract Specifications. Include the following within submittal:

1. Basis for certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. The term "withstand" means the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.

2. Dimensioned outline drawings of equipment unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Submit a detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Design Calculations: Submit design calculations signed and sealed by a registered professional engineer in the State of Washington. Include within the submittal calculations for requirement for seismic anchorage restraints.

E. Equipment Pads: Provide coordinated equipment pad layout and attachment detail working drawings.

F. Submit working drawings and data sheets on all unit substation sections and components including dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

G. Include the following on incoming line section submittal:

1. Working drawings:
   a. Outline and section plans showing components and arrangement.
   b. Incoming primary cable terminations entering from above or below.
   c. Primary termination details of medium voltage cable to transformer.
   d. Transition bus configuration, current, and voltage ratings.
   e. Short-circuit current rating.
   f. Alignment and connection details.
   g. Coordinated transformer primary bushing connections on line side.

2. Factory test reports

H. Medium voltage transformer: Include the following in the submittal:

1. Product data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features and performance for each type and size of transformer indicated.

2. Working drawings:
   a. Outline and section plans showing components and arrangement.
   b. Primary and secondary bus termination details
c. Anchorage details.
d. Diagram power and alarm/signal wiring.

3. Factory test reports.

I. Double ended switchgear section: Include the following in the submittal:

1. Product data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, tools list and performance for each type and size of switchgear indicated.

2. Working drawings:
   a. Outline and section plans showing components and arrangement.
   b. Primary and secondary bus termination details.
   c. Bus configuration, current, and voltage ratings.
   d. Short-circuit current rating of switchgear and overcurrent protective devices.
   e. Switchgear alignment and connection details.
   f. Coordinated transformer secondary bus connections on load side.
   g. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
   h. Mimic-bus diagram.
   i. Features, characteristic, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   j. Wiring diagrams including power, alarm signal, and control wiring.
   k. Load transfer scheme between main circuit breakers and tie circuit breaker during a source outage.

3. Factory test reports.

J. Include the following in the field quality control for unit substation sections and components submittal:

1. Field test data:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

2. Field service reports.
   a. Test procedures used.
   b. Equipment and components inspected.
c. Inspection items.
d. Inspection results and remedies taken.

3. Operation and maintenance manuals for unit substation sections and components.

4. Warranty for unit substation and components.

1.04 QUALITY ASSURANCE

A. Manufacturer's Certification: Ensure a qualified factory-trained manufacturer's representative(s) certifies, in writing, that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. Provide three copies of the manufacturer's representative's certification.

1.05 PROJECT CONDITIONS

A. Conform service conditions to IEEE C37.121, usual service conditions except for the following:

1. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
2. Unusual space limitations:
   a. Product selection for restricted space: Indicate on Contract Plans all dimensions for double ended unit substation sections, including clearances between switchgear and adjacent surfaces and other items. Select products to conform to the maximum dimensions as indicated.

1.06 MAINTENANCE

A. Provide ten copies of the equipment operation and maintenance manuals. Operation and maintenance manuals in conformance with "01-78-23 Operation and Maintenance Data" of these special provisions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Verify the manufacturer is ISO 9000, 9001 or 9002 certified for the double ended unit substation equipment specified herein.

B. Obtain all double ended unit substations and associated components through one manufacturing source. The source manufacturer is responsible for the complete unit substation design; and, is, at a minimum, the manufacturer of the outgoing switchgear sections:

1. Conform all working drawings to industry standard (IEEE) drafting and nomenclature standards.
2. Ensure all working Contract Drawings are reviewed and signed by qualified staff engineer.
3. For the manufacturer of the incoming line section and the outgoing switchgear section use a major medium voltage switchgear manufacturer and have a
2.02 MANUFACTURED UNITS

A. Proposed products with dimensions larger than shown on contract drawings are not be acceptable. Ensure size of the double ended unit substations meet code requirements for the work space and maintenance access clearances.

B. The double ended unit substations: Ensure all substations are of the single unit type complete from the incoming line terminals to the outgoing secondary feeder breakers terminals.

C. For incoming line section use an indoor type, designed in accordance with ANSI C37.30, ANSI C37.35, NEMA SG6 and NEC 2005 including:
   1. Three approved terminals for incoming cables of adequate capacity entering from above or below. Ensure the enclosure is large enough to accommodate built-up tape stress cones.

D. Testing and Identification for use on Emergency Systems

E. Automatic transfer controls between the main circuit breakers and the tie breaker shall be field-evaluated to confirm compliance with UL 1008 or its equivalent for automatic transfer to an emergency system. This evaluation shall be performed by an independent testing organization. The equipment shall also be provided with a label indicating the tests performed and that the equipment has been tested to properly operate on emergency systems.

F. Medium Voltage Transformers
   1. Provide dry-type, 2-winding transformers in conformance with NEMA ST20, ANSI C57.12.50 or ANSI C57.12.51 IEEE C57.12.01. Ensure transformer is UL 1562 listed and labeled.
      a. Use a transformer designed for indoor, ventilated use and vacuum-pressure impregnated, with insulation system rated at 220 degrees C with a 150 degrees C average winding temperature rise above a maximum ambient temperature of 40 degrees C.
   2. Ensure the transformer is rated 3000 kVA base (AA), 26,000-480Y/277V, 3-phase, 60 Hz.
   3. Use a transformer percent impedance of 5.75 or lower.
   4. Conform insulation materials to IEEE C57.12.01, and rated at 220 degrees C.
   5. High-voltage basic impulse level: 150 kV peak, low-voltage basic impulse level: 10 kV peak
   6. Full-capacity voltage taps: four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.
   7. Cooling system:
      a. 150 degrees C: Class AA, self-cooled.
      b. Provisions with Class FA, force-air cooling system.
c. Install fans with this unit. Fans must be installed with this unit to provide sufficient capacity during emergency loading.

8. Do not exceed sound levels listed in NEMA TR 1.

9. Outgoing switchgear bus connections:
   a. Make all equipment chamber secondary connections bussed with transition bus section or bus transition internal to transformer enclosure, with copper bus connection pattern to match switchgear. Provide flex bus connections to switchgear buses.

10. Factory tests: Perform design and routine tests in conformance to standards specified for components. Conduct transformer tests in conformance to ANSI C57.12.50 ANSI C57.12.51 IEEE C57.12.91, as applicable.

11. Perform the following factory-certified tests on each transformer:
   a. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
   b. Ratios on rated-voltage connection and on tap extreme connections.
   c. Polarity and phase relation on rated-voltage connection.
   d. No-load loss at rated voltage on rated-voltage connection.
   e. Excitation current at rated voltage on rated-voltage connection.
   f. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
   g. Applied potential.
   h. Induced potential.
   i. Temperature test: Performed test at lowest kilovolt-ampere Class AA rating. Temperature test is not required if record of temperature test on an essentially duplicate unit is available. Submit test report to the Engineer for review and approval.

12. Transformer protection and control devices:
   a. Protection and indicating devices shall be provided as shown on the contract drawings and as specified herein.
   b. Winding temperature gauges shall be provided and mounted for viewing from outside of the transformer enclosure through viewing window. The temperature gauge shall be provided with two stage contacts. First stage contact shall be for remote annunciation and second stage for tripping the associated circuit breaker as indicated on the contract drawings.
      1) The pickup point of the first stage shall be adjustable and factory set so that upon a designated temperature increase the device initiates an alarm.
      2) Further temperature increase, the device shall initiate the tripping of the associated circuit breaker.
G. Switchgear Section

1. Front-and rear-accessible switchgear: Front or rear aligned as noted, with features as follows:
   a. Service rated and as indicated on the Contract Drawings.
   b. Main – tie- main and feeder breakers: Drawout mounted.

2. Nominal system voltage: 480Y/277 V.

3. Main-bus continuous current: As shown on plans.

4. Fabricate and test switchgear in conformance to IEEE 344 to withstand seismic force defined in IBC and as indicated on structural drawings.

H. Enclosure: Steel, NEMA 12.

1. Enclosure finish for indoor units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2. Barrier: Between adjacent sections.

3. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

4. Bus transition sections: Matched and aligned with basic switchgear.

5. Removable, hinged rear doors and compartment covers: Secured by captive thumb screws, for access to rear interior of switchgear.

6. Hinged front panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

7. Buses and connections: Three phase, three wire, unless otherwise indicated:
   a. Phase bus material: Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections. Use copper for feeder circuit-breaker line connections.
   c. Ground bus: 1/4-inch by 2-inch minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors.
   d. Contact surfaces of buses: Silver plated.
   e. Main phase buses and equipment ground buses: Uniform capacity of entire length of switchgear's main and distribution sections. Provide for future extensions from both ends.
   f. Isolation barrier access provisions: Permit checking of bus-bolt tightness.
I. Future devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

J. Bus-bar insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating: 105 degrees C.

K. Main and Tie Circuit Breakers.

1. Description: Comply with IEEE C37.13.1.

2. Comply with NEMA standard ICS10-1193- AC Automatic Transfer Switches

3. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

4. Operating mechanism: Mechanically and electrically trip-free, store-energy operating mechanism with the following features:
   a. Normal closing speed: Independent of both control and operator.
   b. Slow closing speed: Optional with operator for inspection and adjustment.
   c. Store-energy mechanism: Electrically charged, with optional manual charging.
   d. Operation counter.

5. Trip devices: Solid-state, overcurrent trip-device system including one or two current transformers or sensors per phase, a release mechanism, and the following features:
   a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
   b. Field-adjustable, time-current characteristics.
   c. Current adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
   d. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
   f. Pickup points: Five minimum with "off", for instantaneous-trip functions.
   g. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for three-wire circuit or system where shown on the Contract Drawings.
   h. Trip indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
6. Use Auxiliary contacts for interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation. Provide quantity as indicated. Include with each two Type "a" and two Type "b" stages (contacts) wire through secondary disconnect devices to a terminal block in stationary housing.

7. Drawout features includes a circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test and disconnected positions and includes the following features:
   a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test or disconnected position.
   b. Circuit-breaker positioning: An open circuit breaker may be racked to or from connected, test, and disconnected position only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
      1) Test position: Primary disconnect devices disengaged and secondary disconnect devices and ground contact engaged.
      2) Disconnected position: Primary and secondary devices and ground contact disengaged.

8. Arc chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

9. Padlocking provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

10. Electric close button: One for each electrically operated circuit breaker.

11. LED indicating lights: To indicate circuit breaker is open or closed, for main circuit breaker interlocked with external devices.

12. Conform instrument transformers to NEMA EI 21.1, IEEE C57.13, and include following:
   a. Potential transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
   b. Current transformers: Use ratios as indicated, with accuracy class and burden suitable for connected relays, meters, and instruments.
   c. Control-power transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
   d. Provide 2-percent accuracy, 3-phase, 4-20 mA current transducer for secondary main bus, with output wired to field terminal block.

12. Provide electrical interlock between Main-Tie-Main breakers such that only two breakers can be closed at one time. Tie breaker can be closed only if one of the main is open.
L. Feeder Circuit Breakers

1. Comply circuit breakers with the requirements of IEEE C37.13.1, ANSI C37.16, ANSI C37.17, ANSI C37.50, UL 1066, NEMA SG3. For all breakers use three-pole, 100 percent rated.

   a. Ensure circuit breaker element have Connected, Test, and Disconnected position indicators, Spring Charge/Discharged indicators, and circuit breaker Open or Closed and Ready-to-Close indicators all of which are visible to the operator with the compartment door closed. Make it possible to rack the circuit breaker element from the connected to the disconnected position with the compartment door closed.

   b. Provide interlocks to prevent racking the circuit breaker unless the breaker is open.

2. Rating: Use continuous interrupting and ratings as indicated. Use circuit breaker of 600-volt class.

3. Operating Mechanism: Mechanically and electrically trip-free, store-energy operating mechanism with the following features:

   a. Normal Closing Speed: Independent of both control and operator.

   b. Electrical operator, field installable with manual charging.

   c. Operation counter.

4. Ensure each low voltage power circuit breaker is equipped with self-powered, microprocessor-based trip-device to sense overload and short circuit conditions. Ensure the device measures true RMS current and the tripping system includes sensors on each phase, a release mechanism, and the following features:

   a. Field Installable & Interchangeable so that any trip unit can be used with any frame size circuit breaker. And can be upgraded for future expansion in functionality, such as communication.

   b. Functions: Provide long time, short time and extended instantaneous protection function to allow the breaker to be applied at the withstand rating of the breaker. Ensure each breaker has an adjustable pick-up setting. In addition, ensure long time and short time bands each have adjustable time delay. Include a switchable \( I^2t \) ramp for short time function.

   c. Make a software program free of charge to support system co-ordination. The software will allow time current curves to be generated for the chosen settings.

   d. Use individual LED's to indicate an overcurrent, short circuit or ground fault trip condition. Maintain the data for a minimum of 48 hours without the need for a separate battery.

   e. Allow time-current characteristics to be field adjustable locally.

   f. Current Adjustability: Dial settings and rating plugs on trip units.

   g. Pickup Points: 10 Long Time Settings.
h. Field Installable Ground-Fault protection with at least three time-delay bands; adjustable current pickup and an I²t ramp. Arrange to provide protection for three-wire service.

i. Field installable zone selective interlocking: Connections will be made between main and feeder circuit breakers to ensure that the circuit breaker closest to the fault trips for short time and ground fault conditions.

j. Make A LCD display available to simplify settings & viewing data locally.

5. Make mechanism operated cell switch to be operated by the circuit breaker operating mechanism.

6. Make terminal Block Connections, front mounted and with ring tongue terminal.

7. Padlocking provisions for installing at least three padlocks on each circuit breaker to prevent movement of the draw-out mechanism.

8. Built in operating handle complete with handle and integral to breaker. Ensure no external tools are required to rack the breaker.

9. Provide control switch for each electrically operated circuit breaker. Provide each control switch with red (closed) and green (open) status indicating lights mounted on the head front panel. Provide a minimum of two normally closed and two normally open auxiliary controls for remote position indication and equipment control unit comes complete with a shunt trip relay.

10. Make undervoltage trip adjustable time-delay.

11. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.

12. Control circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.

13. Control-power fuses: Fuses for protection of control circuits.

14. Control wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

M. Accessory components and features

1. Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
   a. Racking handle to manually move circuit breaker between connected and disconnected positions.
   b. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.


3. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
4. Each main feeder shall be monitored with a metering device that monitors the following: local display of 3-phase voltage, current, and frequency; system and per-phase power including watthours, varhours, and VA-hours; system demand including watt demand, VA demand, and var demand; apparent and displacement power factor; and recorded minimums and maximums of these values. The monitored parameters for voltage shall be L-L and L-N true rms measurement, and for amps it shall be provided for each phase. The meter shall be installable on the face of the switchgear and shall be integral with the equipment. The meter shall have interface capability to a computer network for data collection, storage, and/or printout.

N. Factory test:

1. Perform standard factory tests on the equipment under this section. Conform all tests to ANSI and NEMA standards. Ensure the manufacturer provides 3 certified copies of factory test reports.

O. Factory finish:

1. Prior to assembly, thoroughly clean and phosphatize all enclosing steel. Electrostatically apply a powder coating, then fused on by baking in an oven. Apply coating to have a thickness of not less than 1.5 mils. Ensure the finish has the following properties:
   a. Impact resistance: ASTM D2794: 60 direct/60 indirect
   b. Pencil hardness: ASTM D3363: H
   d. Salt spray: ASTM B117: 600 hours
   e. Color: ANSI 61: gray

P. Identification

1. Substation nameplates: Label substation incoming line section, transformer section and outgoing switchgear section compartments to conform to Section 26 05 53, Identification for Electrical Systems

2. Mimic bus: Apply continuously integrated mimic bus to the front of the switchgear. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram. Coordinate mimic-bus segments with devices in the section to which they are applied. Produce a concise visual presentation of principal components and connections:
   a. Mimic bus: Apply continuous mimic bus to the front of switchgear, arranged in single-line diagram format, using symbols and lettered designations consistent with approved final mimic-bus diagram.
   b. Medium: Painted graphics, as approved.
   c. Color: Contrasting with factory-finish background; selected by Engineer.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Ensure the unit substation assembly and switching components are certified to conform to applicable seismic requirements of IBC and as indicated on structural drawings.

B. Install each unit substation in a prepared concrete pad inside the substation building as indicated on the Contract Drawings.

C. Identify field installed conductors, interconnecting wiring and components and provide wiring signs in conformance with Section 26 05 53, Identification for Electrical Systems, and as indicated on the Contract Drawings.

D. Ground equipment: Section 26 05 26, Grounding and Bonding for Electrical Systems, and as indicated on the Contract Drawings.

E. Wiring Connections: Section 26 05 25, Wire and Cable.

3.02 FIELD QUALITY CONTROL

A. Test the installed Double Ended Unit Substations in accordance with Section 26 08 00, Commissioning of Electrical Systems.

B. Prepare for acceptance tests as follows:

1. Test insulation resistance for each substation bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Manufacturer's field service: Engage a factory-authorized service representative to inspect cable connections and to assist in field testing. Report results in writing:

1. Verify the manufacturer's representative(s) is knowledgeable of each section of the unit substations.

2. Ensure the manufacturer's representative provides technical direction and assistance to the Contractor in cable connections and testing of the assembly and components contained therein.

3. Ensure the manufacturer's representative provides three copies of a written report on the operational testing of the equipment in accordance with the manufacturer's written instructions. Ensure the manufacturer's representative lists inspections and tests conducted and all results, including any problems found and how they were rectified. Ensure the manufacturer's representative certifies equipment is ready for acceptance testing.

D. Testing agency: Engage a qualified Independent Testing Laboratory to perform the following field tests and inspections and prepare test reports:

1. Use Independent Testing Laboratory and testing technician qualified in conformance to Section 26 08 00, Commissioning of Electrical Systems.

2. Ensure Independent Testing Laboratory performs visual and mechanical inspection and electrical test stated in NETA. Certify conformance to test parameters.
3. Ensure the Independent Testing Laboratory tests transformer in conformance with NETA 7.2.1.

4. Ensure the Independent Testing Laboratory tests incoming and outgoing switchgear in conformance with NETA, as appropriate.

5. Ensure the Independent Testing Laboratory sets field-adjustable circuit-breaker trip ranges.

6. Ensure the Independent Testing Laboratory tests and adjust controls and safeties.

7. Ensure the Independent Testing Laboratory performs the following infrared scan test and inspections and prepares reports:
   a. Initial infrared scanning: After final inspection of the contract, but not more than 60 days after acceptance of contract, ensure the testing agency performs an infrared scan of each unit substation. Ensure the Independent Testing Laboratory removes front and rear panels so joints and connections are accessible to portable scanner.
   b. Follow-up infrared scanning: Ensure the Independent Testing Laboratory performs an additional follow-up infrared scan of each unit substation 11 months after date of substantial completion.
   c. Ensure the Independent Testing Laboratory uses an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Ensure the Independent Testing Laboratory provides calibration record for device.
   d. Ensure the Independent Testing Laboratory prepares a certified report that identifies unit substations included and that describes scanning results. Ensure the Independent Testing Laboratory includes notation of deficiencies detected, remedial action taken, and observations after remedial action.

E. Remove and replace malfunctioning units and components and retest as specified above.

1. Test reports: Prepare written reports to record the following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.
   d. Provide three copies of the test report.

F. Voltage monitoring and adjusting: Perform the following voltage monitoring as a part of the overall systems commissioning, after all system components have been tested and accepted:
1. During a full load test, record for 10 minutes, the three-phase voltage at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 25 mm per hour. Voltage imbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.

G. Corrective actions: If test results are unacceptable, perform the following corrective actions, as appropriate:

1. Adjust transformer taps.

H. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.

I. Reports: Prepare a written report covering monitoring and corrective actions performed.

3.03 CLEANING

A. On completion of installation, inspect interior and exterior of the unit substations. Remove paint splatters and other spots. Vacuum dirt and debris and do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to Sound Transit’s maintenance personnel to adjust, operate, and maintain unit substations, switching controls, overcurrent protective devices, instrumentation, and accessories. Provide up to two training classes of 4 hours each, including instruction materials.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing and installing enclosed circuit breakers, circuit breaker panelboards and load centers, and switchboards.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 26 05 00, Common Work Results for Electrical

2. Section 26 08 00, Commissioning of Electrical Systems

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. American National Standards Institute (ANSI):

   a. ANSI C39.1 Requirements for Electrical Analog Indicating Instruments


   a. ASTM A 653/A 653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

   b. ASTM B 187 Specification for Copper Bar, Bus Bar, Rod and Shapes

3. Institute of Electrical and Electronics Engineers (IEEE):


4. National Electrical Contractors Association (NECA):

   a. NECA 400 Recommended Practice for Installing and Maintaining Switchboards

5. National Electrical Manufacturers Association (NEMA):

   a. NEMA PB 1 Panelboards

   b. NEMA PB 2 Deadfront Distribution Switchboards

   c. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

a. NFPA 70 National Electrical Code

7. Underwriters Laboratories (UL):
   a. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: Submit manufacturers' product data for specified equipment and materials. Include the following information for each item:
   1. Manufacturer's model number or item identification;
   2. UL listing and rating;
   3. Critical dimensions and mounting arrangement; and
   4. Replacement parts list.

C. Shop Drawings: Submit shop drawings and electrical diagrams as follows:
   1. Panelboards and Load Center:
      a. Show general arrangement, location, and identification of the enclosure.
      b. Identify each circuit.
      c. Show location and identification of terminals.
      d. Show location of barriers.
      e. Provide wiring diagrams.
      f. Enclosures: Show materials and methods of construction, door arrangement, conduit hubs, and knockout locations.
   2. Circuit Breakers: Show circuit for which intended, voltage ratings, insulation level, current rating, and interrupting ratings.
   3. Switchboards
      a. Single line diagrams;
      b. Physical arrangement drawings, and weight of equipment and major components;
      c. Unit wiring diagrams;
      d. Show space available for conduit entrance and for routing and training of cables. Take into consideration bending radius requirements of cables when determining available space;
      e. Schematic diagrams for electrically operated equipment;
      f. Setting diagrams and templates if anchoring in concrete is required;
g. Assembly and erection diagrams if shipped in sections or if any parts are shipped separately and not installed at the factory; and

h. Interconnection diagrams for circuits having externally located instruments, controls, alarms, or similar devices.

D. Operation and Maintenance Data: Submit data in accordance with Section 01 78 23, Operation and Maintenance Data, including the following requirements:

1. Description of the switchboard and its components;

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram for components;

3. Recommended list of spare parts;

4. Wiring diagram;

5. Electrical characteristics of each component including relays or solid-state circuitry; and

6. Relay coordination curves.

E. Test Reports: Submit copies of certified reports of factory and field tests performed in accordance with the applicable referenced standards and specification requirements.

F. Shipping Record: Submit impact record chart to the Resident Engineer.

1.04 QUALITY ASSURANCE

A. Select a manufacturer who has been regularly engaged in the manufacture of similar equipment and has met UL requirements.

B. Conform to UL 489, NEMA PB 1, and National Electrical Code, as applicable.

C. Provide interchangeable components of the same type, size, rating, functional characteristics, and manufacture.

D. Verify each item is UL labeled.

1.05 DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store in secure and dry storage facility.

C. Special requirements for switchboards

1. Clearly label temporary internal bracing of equipment as "Temporary Bracing: To Be Removed Before Operation."

2. Use a mechanical impact recorder during shipment, capable of registering maximum acceleration.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Enclosed Circuit Breakers:

1. UL 489, molded case, quick-make quick-break bolt-on type, with thermal-magnetic type overload trip, interchangeable unit for frame rated 125 A and above.

2. Enclosure: NEMA 250 Type 12, fabricated from galvanized steel, surface-mounted unless otherwise indicated.

3. Finish: metallic surface thoroughly cleaned, degreased, primed with an approved corrosion-inhibitive primer, and then finished with heavy-duty, industrial-grade polyurethane enamel.

B. Panelboards and Load Centers: NEMA PB 1.

1. Enclosure: NEMA 250 Type 12, fabricated from galvanized steel, surface-mounted unless otherwise indicated, tamperproof, with the following additional requirements:

   a. Gutter size:

<table>
<thead>
<tr>
<th>Rating Amperes</th>
<th>End Gutter Size (Inches)</th>
<th>Side Gutter Size (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>225 and below</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>400 and over</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

   b. Provide backplate of reinforced steel for mounting of interior components.

   c. Provide device or mechanism for enclosure grounding.

2. Cover and Trim:

   a. Designed for surface or flush mounting as indicated.

   b. Adjustment: Provide flush-mounted panelboards with means to plumb and align the front of the panel with respect to the adjacent finished surfaces.

   c. Door: Hinged, fitted with a combination latch and door lock, accommodating a master key. Provide one flat key tumbler cylinder-type, nickel-plated door lock conforming to the station master key system, two keys per lock.

   d. Circuit Directory: Provide a directory frame with acrylic plastic face mounted on the back of the door.

   e. Finish: metallic surface thoroughly cleaned, degreased, primed with an approved corrosion-inhibitive primer, and then finished with heavy-duty, industrial-grade polyurethane enamel.

a. Provide neutral bus of the same rating as that of phase bus.

b. Provide a grounding bus.

4. Circuit Breakers

a. Bolt on type.

b. Auxiliary contacts: Ensure circuit breakers in tunnel lighting and power panels have auxiliary contacts and that these contacts are paralleled to provide a common "panel trouble" alarm locally and monitoring by SCADA (SCADA interface by others).

C. Switchboards:

1. Metal-enclosed, self-supporting, dead front, freestanding, circuit-breaker type for indoor service. Comply with NEMA PB 2, the National Electrical Code, and the authority having jurisdiction.

2. Provide the required number of vertical sections designed for bolting together to form a rigid switchboard.

3. Ensure switchboards are assembled, wired, and tested at the manufacturer's plant. If approved by the Resident Engineer, switchboards may be broken down into convenient shipping sections subsequent to the completion of the tests. Ensure split terminals and connections disconnected for shipping are properly identified and protected.

4. Ensure switchboards in the same line-up fed electrically from different feeders are installed with barriers such that a fire caused by an internal fault at one switchboard can not spread to another switchboard.

5. Current rating: Based on operation in a 25 degrees C room ambient.

6. Enclosure: Freestanding type, designed for group assembly to be part of complete indoor ac distribution, with the following additional requirements:

7. Physical Size: 90 inches high, with width and depth adequate to accommodate and connect the equipment. Align vertical sections front and rear, and equip with rear doors.

8. Reinforce with adequate steel framework to form a rigid structure with a smooth outer surface free from burrs, ridges, and other blemishes.


10. Finish: To finish metallic surfaces, clean, degrease, treat with hot phosphate chemical bath, prime with corrosion-inhibiting undercoat primer, and paint with finish coat of heavy-duty, industrial-grade, polyurethane enamel, in standard color as selected by the Resident Engineer.

11. Nameplates:

a. Provide a nameplate on each switchboard and its components as indicated.
b. Attach laminated plastic nameplates by means of stainless steel machine screws or rivets, or permanent adhesive.

c. Label each switchboard section with 4-inch wide nameplate showing switchboard number in 2-1/2-inch high white cut-in letters on black background.

d. Label each control switch and pilot light with 1-inch wide nameplate showing the function and the number of unit in 1/2-inch high white cut-in letters on black background.

12. Space Heater: Provide a thermostatically controlled space heater having capacity sufficient to maintain interior temperature above dew point in each cubicle. Space heater rated voltages as follows:

a. Heaters 1.8 kW and over: 480 V, 3 phase.

b. Up to 1.8 kW: 208 V, 3 phase.

c. Up to 200 W: 120 V, single phase.

D. Switchboard Circuit Breakers:

1. Fixed-mounted, insulated-case, stored energy, electrically operated type, 3 phase, 60 Hz, in accordance with NEMA PB 2.

2. Maximum of 5-cycle closing time.

3. Equip with solid-state trip unit with voltage and current sensors as indicated, and a minimum of seven time/current systems coordination adjustment, including ground fault and undervoltage settings.

4. Ensure insulation rating of plug is the same as the breaker rating.

5. Ensure circuit breakers are capable of performing 4,000 close-open cycles at rated load, 80 percent power factor and rated voltage, and 4,000 close-open cycles at no load without maintenance or replacement of parts.

6. Ensure Breakers have control power and motor charging device of 120 V ac.

7. Equip breakers with field-replaceable contacts.

E. Switchboard Buses:

1. Provide silver-plated copper buses of sufficient size to limit the current density to 750 A per square-inch cross section.

2. Brace distribution switchboard buses for the symmetrical fault current indicated.

3. Main Buses: Extend main buses horizontally from the incoming line sections to all distribution sections if indicated on the same line-up. Make provision for extending the main buses for future vertical sections.

4. Section Buses: Extend section buses vertically from the main bus through each vertical section.

6. Ground Buses: Extend a ground bus through the length of the switchboard and firmly bolt to each vertical section in at least two places. Make provision for connection to the building or station grounding system near each end of the ground bus. Make provision for future extension of the ground bus.

7. Phasing: Phase buses A-B-C from left-to-right, top-to-bottom, and front-to-rear as viewed from the front of the switchboard.

F. Switchboard Instruments, Control, and Accessories:

1. Potential Transformers: IEEE C57.13, wound type with polarity markers, suitable for operating meters and relays.
   a. Voltage: 120 V secondary.
   b. Insulation class: 600 V with basic impulse insulation level of 10 kV full wave.
   c. Temperature Rise: Ensure that the maximum allowable temperature rise not exceed 55 degrees C under continuous full load above an average ambient temperature of 25 degrees C.
      
      1) Winding average: 30 degrees C.
      2) Hottest spot in winding: 40 degrees C.

G. Current Transformers:

1. Type: Bushing or epoxy encapsulated wound.
2. Comply with IEEE C57.13 requirements for relaying accuracy classification under the burdens imposed by the devices specified or implied herein.
3. Use current transformers capable of withstanding thermal and magnetic stresses from the flow of the interrupting and momentary currents of the circuit breakers.
4. Locate current transformers in a separate compartment isolated from the meter section. Provide metallic shielding to protect current transformers and secondary wiring from induced voltages and to minimize the possibility of insulation failure.
5. Supply secondary terminal blocks with covers that have integral shorting bars. Connect secondary wiring to readily identifiable terminal block points in the control compartment. Ensure terminal block points have integral shorting bars for the current transformer leads.
6. Ensure current transformers have a mounting frame bolted securely to the switchgear frame.

H. Meters:

1. Type: ANSI C39.1, square, taut band, transformer rated, ironvane.
2. Dial: Approximately 4-1/2 inches square, graduated from zero to full range with black figures on white background.
3. Voltmeter rating: 600 V.
4. Ammeter rating: 125 percent of circuit rating, or as indicated.
5. **Accuracy Class:** 1 percent of full scale.

I. **Relays:**
   1. Provide one lock-out relay for preventing the breaker from reclosing after abnormal conditions, except undervoltage.
   2. Provide one time delay relay, adjustable from 0 to 6 seconds, for use with undervoltage relay.

J. **Control Switches:**
   1. Provide control switch as required and indicated.
   2. Provide relay test switch.
   3. Provide manual pushbutton at the front of breaker housing for testing breaker.

K. **Control and Instrumentation Wiring:**
   1. Factory Installed
   2. Wire: Type SIS tinned copper wire not smaller than 14 AWG. For wiring across hinged joints use Class D stranded wire, not smaller than 12 AWG.
   3. Wire Terminals: Tinned copper ring compression terminals with insulated sleeve installed in accordance with the manufacturer's recommendations.
   4. Terminal Blocks: Provide washerhead screws suitable for ring compression terminals with insulated sleeve. Provide a minimum of 10 percent spare terminals.
   5. Position Switch and Auxiliary Contacts: Provide position switch and breaker auxiliary contacts as indicated.
   6. Wire Connections: Wire controls, relays, and metering circuit terminals requiring external connections to accessible terminal blocks. Provide interconnecting wires terminated on terminal blocks in each cubicle.
   7. Wire Identification: Provide each wire with plastic sleeve, attached within 6 inches of terminal connections, and printed with the number indicated on the wiring diagrams.

L. **Fuses:** Provide current limiting fuse in each control circuit.

2.02 **SOURCE QUALITY CONTROL**

A. In addition to the manufacturer's standard tests, as a minimum perform the following tests at the manufacturer's plant:
   1. 60 Hz dielectric tests;
   2. Mechanical operations tests;
   3. Grounding of instruments;
   4. Transformer case tests;
   5. Electrical operation tests; and
PART 3 - EXECUTION

3.01 INSTALLATION

A. Mounting Height: Install with top 6 feet, 6 inches above the floor and the bottom not less than 12 inches above the floor, unless specifically indicated otherwise. Use multisectional panelboards and load centers to meet these spacings if necessary. Line up tops of trims to present neat appearance.

B. Anchor in accordance with seismic requirements in Section 26 05 00, Common Work Results for Electrical.

C. When a feeder serves more than one panelboard or panelboard section, install a separate junction box or provide adequate gutter area for termination of feeders and bus taps.

D. Connect neutral wires of branch circuits to the neutral bar of the same panelboard as the branch circuit.

E. When circuit breakers are located in spaces other than the main electrical distribution system equipment rooms and used to protect conductors serving emergency equipment motors (such as fans, dampers, and pumps), emergency lighting, and communications equipment, ensure they not be tripped by the thermal element. Use thermal element contact to indicate an alarm condition.

F. Provide nameplates or other permanent identification for each circuit breaker, mounted on the cover or trim adjacent to each breaker, in accordance with Section 26 05 53, Identification for Electrical Systems.

G. Provide each panelboard and load center with an accurate typewritten circuit directory. Install in the factory-provided directory frame mounted on the back of the door.

H. Anchor in accordance with seismic requirements in Section 26 05 00, Common Work Results for Electrical.

I. Install switchboards in the locations indicated in accordance with NECA 400.

J. Install switchboard on concrete floor with leveling channels.

K. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

L. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the switchboard.

M. Exercise special care during construction to avoid overloading any part of the structure. Repair or replace items damaged due to overloading.

N. Field Touch up Painting: After installations are complete, thoroughly clean surfaces where shop finish is damaged, including bolts, nuts, washers and welds, and paint each item with the same paint system as used for shop painting. Provide touch-up painting by approved spray methods, or by brush where spray-painting is not practical.
O. Energizing Switchboards:

1. Perform pre-energizing checkout procedure in accordance with NECA 400 prior to energizing switchboards.

2. Notify Resident Engineer prior to energizing switchboards.

3. Energize switchboards in accordance with NECA 402.

3.02 FIELD QUALITY CONTROL

A. Provide equipment for testing power and control circuits after installation. Test under the observation of the Resident Engineer.

1. Panelboards and Enclosed Circuit Breakers:

   a. Test the installed Panelboards in accordance with Section 26 08 00, Commissioning of Electrical Systems

   b. Test circuits for connections in accordance with the wiring diagram.

   c. Test that insulation resistance to ground of nongrounded conductors is a minimum of 10 megohms.

   d. Test panelboard and load center enclosures for continuity to the grounding system.

   e. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2 hour.

   f. Test that each panel has a balanced load.

   g. Maintain a log of tests.

2. Switchboards:

   a. Test the installed Switchboards in accordance with Section 26 08 00, Commissioning of Electrical Systems

   b. Verify that circuits are connected in accordance with the applicable wiring diagrams.

   c. Verify that circuits are continuous and free from short circuits.

   d. Verify that the insulation resistance to ground of non-grounded conductors is megger tested to not less than 10 megohms.

   e. Verify that the completed equipment grounding system is megger tested at each service disconnect enclosure ground bar to ensure connection to ground.

   f. Verify that circuits are operable. Conduct tests to include operating each control not less than ten times, and the continuous operation of each lighting and power circuit for not less than 1/2 hour.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing and installing individual enclosed motor soft starters for Emergency Ventilation Fans and Smoke Exhaust Fans, including all components for fully functional self contained units ready for field installation and wiring as indicated in the Contract Drawings.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 26 05 00, Common Work Results for Electrical
2. Section 26 05 53, Identification for Electrical System
3. Section 26 08 00, Commissioning of Electrical Systems

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

   a. ASTM A653/A653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   b. ASTM D2092 Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting

2. Institute of Electrical and Electronics Engineers (IEEE):
   a. IEEE 344 Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

3. National Electrical Contractors Association (NECA)
   a. NECA 402 Recommended Practice for Installing and Maintaining Motor Control Centers

4. National Electrical Manufacturers Association (NEMA):
   a. NEMA ICS 1, General Standards for Industrial Control and Systems
   b. NEMA ICS 1.1, Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control
c. NEMA ICS 2, Industrial Control Devices Controllers and Assemblies

d. NEMA ICS 4, Terminal Blocks for Industrial Control

e. NEMA ICS 6, Industrial Controls and Systems Enclosures

f. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)

5. Underwriters Laboratories, Inc. (UL):

a. UL 508, Industrial Control Equipment.


a. NFPA 70, National Electrical Code

b. NFPA 130, Fixed Guideway Transit and Passenger Rail Systems

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Shop Drawings: Submit shop drawings and electrical diagrams, including point to point wiring diagrams. Identify electrical characteristics and ratings of all component assemblies on shop drawings.

C. Product Data: Submit manufacturer's product data of manufactured materials and equipment.

D. Operational and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operation and Maintenance Data, including the following requirements:

1. Description of the equipment and its components;

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram of components;

3. Recommended list of spare parts; and

4. Wiring diagrams.

E. Test Reports: Submit certified test reports of shop and field tests performed, verifying that performance of equipment meets specification requirements.

F. Warranties

1.04 DELIVERY, STORAGE, AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage or distortion.

B. Store motor soft starters in secure and dry storage facility.

1.05 MEASUREMENT AND PAYMENT

A. The work of this Section consists of providing complete and fully operable enclosed controllers/soft starter units for Emergency Ventilation Fans and Smoke Exhaust Fans as
described in this specification, and as indicated on the Contract Drawings. The scope shall include controller enclosure design, fabrication, component procurement and assembly, circuit design, wiring, software design and programming, furnishing, installing, shop and field testing, and commissioning.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. The low voltage enclosed motor controllers shall be manufactured by any of the following:

1. Allen-Bradley
2. Eaton/Cutler Hammer
3. ABB
4. GE
5. Or approved equal

2.02 MATERIALS

A. Motor Soft Starter Units

1. Ensure motor starters meet the requirements of NEMA ICS 2, general purpose Class A, and the following additional requirements:

   a. Rating: Continuous current rating suitable for associated motors as follows:

      1) Emergency Ventilation Fans (EMFN) – 400hp
      2) Smoke Exhaust Fans (SEFN) – 100hp


   a. Type: For damp and dusty indoor location: NEMA 250, Type 12. Enclosure shall be free standing, bolted to the 4” high maintenance concrete pad


   c. Finish: Painted finish for all ferrous and galvanized metal surfaces.

      1) Prepare ferrous metal surfaces for painting in accordance with standard industry practice.

      2) Prepare galvanized metal surfaces for painting in accordance with ASTM D2092.

      3) After pretreatment, prime-paint surfaces with an approved corrosion-inhibitive metal primer for ferrous or galvanized surfaces, as applicable.
4) For the finish coat use heavy-duty, industrial-grade polyurethane enamel.

d. Dimensions: Per manufacturer.

e. The enclosure shall have full length hinged and gasketed front door with full length piano hinge and three point lockable door latching mechanism.

f. The door shall have a cut-out suitable for a panel/door mounted Motor Protection Relay (MPR) as shown on the Contract Drawings.

B. Motor Soft Starters for Emergency Ventilation Fans (MSS-EMFN)

1. MSS-EMFN units shall contain the following internal components:

a. Fused Disconnect Switch

b. Soft Starter with By-Pass Contactor

c. Reversing Contactors

d. Motor Protection Relay

e. Control Power Transformer

f. DC Power Supply – for soft starter.

g. Terminal Blocks for internal & external control, protection and instrumentation wiring

h. Internal control, protection and instrumentation wiring.

i. Internal power interconnections

j. Provisions for external power wiring

2. Fused Disconnect Switch:

a. Type: Rotary, base mounting, fusible switch.

b. Frame: F

c. Current Rating: 800 Amp

d. Rated Voltage: 600 Volt, 3 Phase, 60 Hertz

e. Maximum 3-Phase Horsepower Rating at 480V: 400hp

f. Short Circuit Rating: 200kA

g. Fuse Type and Rating: Type J, 800A (for short-circuit and ground fault protection)

h. The disconnect switch shall be UL Approved.

i. Provide disconnect switch with heavy duty pistol handle and terminal lugs for three (3) 300kcmil cables per phase at line and load connections.
3. Soft Starter with By-Pass Contactor
   a. Type: Severe Duty Open type Multi-functional, Programmable, Reduced Voltage, Solid-State Motor Starter (Soft Starter).
   b. Frame Size: V
   c. Current Rating: 600 Amp
   d. Operating Voltage: 200 - 600 Volt, 3 Phase, 60 Hertz
   e. Maximum 3-Phase Horsepower Rating at 460V, 60 Hertz and 1.15SF: 450hp
   f. Ramp Time: 30 seconds
   g. Adjustable Ramp Time Range: 0.5 – 180 seconds
   h. Ramp Current: 450% of FLA
   i. Starts per Hour: 4
   j. Control Power: 24Vdc
   k. Auxiliary Contacts: 1 Class A and 1 Class C rated for 120Vac, 3amp.
   l. The Soft Starter shall be UL Listed.
   m. Provide Soft Starter with built-in Run Bypass Contactor and terminal lugs for three (3) 4/0 cables per phase at line and load connections.

4. Reversing Contactors
   a. Type: Open type, Vertical Reversing Contactor
   b. NEMA Size: 6
   c. Current Rating: 600 Amp
   d. Short Circuit Rating: 100 kA (with Class J Fuse specified above)
   e. Operating Voltage: 600 Volt, 3 Phase, 60 Hertz
   f. Maximum 3-Phase Horsepower Rating at 460V, 60 Hertz: 400 hp
   g. Coil Voltage / Hz: 120 Volt 60, Hertz
   h. Auxiliary Contacts: Type W Auxiliary Contact Modules with four (4) NO and four (4) NC contacts rated for 120Vac, 6 amp; for customer wiring.
   i. The Reversing Contactor shall be UL Listed.
   j. Provide Reversing Contactor with built-in Mechanical Interlock, inter-connecting bus-bars and terminal lugs for three (3) 300kcmil cables per phase at line and load connections.

5. Control Power Transformer
a. Control power shall be 120 Vac obtained from integral control power transformer (CPT). Include control power transformer with adequate capacity to operate connected control, indication and protection devices, plus 100 percent spare capacity.

b. The dry-type CPT shall be a minimum of 1000 VA, 480 -120V, single phase, 60 Hertz.

c. Appropriately sized primary and secondary fuses shall be provided.

d. The primary side of the control power transformer shall be protected by current limiting fuses sized according to the requirement.

e. The secondary side of the control power transformer shall be fused appropriately to protect the transformer from overloads.

f. The standard control circuit shall have one leg of the secondary grounded.

6. DC Power Supply

a. Provide a 24Vdc power supply for the soft starter

b. Input/Output: 115Vac input, 24Vdc output

c. Steady state wattage: As required, a minimum of 55W

d. Inrush wattage: 250W

7. Terminal Blocks for internal & external control, protection and instrumentation wiring

a. Terminal blocks shall be double-row collar type screw terminals with spring action overlapping top plates rated for 30 amperes, 600 volts with barrier strips between each adjacent row of terminal positions. Terminal blocks shall conform to NEMA ICS-4 and UL 50. Each terminal shall have a white marking strip and plastic cover.

b. Provide terminal blocks with sufficient terminal points for all required wiring interconnections.

c. Provide 25 percent spare terminals. Mount terminal blocks securely to bracket assembly with stainless steel screws and washers. Terminals shall be grouped and segregated for different operating voltages.

d. Verify that each terminal block is able to accommodate two 14 AWG wires.

8. Internal control, protection and instrumentation wiring.

a. For the control wiring inside the controller enclosure use minimum 16 AWG, stranded, thermoplastic-insulated wire, rated 105 degrees C, with red color for ac.

9. Internal power interconnections

a. Internal power interconnections shall be made with insulated bus-bars or insulated cable rated for motor FLA.
10. Provisions for external power wiring
   a. The controller Line and Load terminals arrangement shall allow adequate space for field termination of external power wiring.

C. Motor Soft Starter for Smoke Exhaust Fans (MSS-SEFN)

1. MSS-SEFN units shall contain the following internal components: 
   a. Fused Disconnect Switch
   b. Soft Starter with By-Pass Contactor
   c. Motor Protection Relay
   d. Control Power Transformer
   e. DC Power Supply – for soft starter.
   f. Terminal Blocks for internal & external control, protection and instrumentation wiring
   g. Internal control, protection and instrumentation wiring.
   h. Internal power interconnections
   i. Provisions for external power wiring

2. Fused Disconnect Switch:
   a. Type: Rotary, base mounting, fusible switch.
   b. Frame: V
   c. Current Rating: 200 Amp
   d. Rated Voltage: 600 Volt, 3 Phase, 60 Hertz
   e. Maximum 3-Phase Horsepower Rating at 480V: 125hp
   f. Short Circuit Rating: 200kA
   g. Fuse Type and Rating: Type J, 200A (for short-circuit and ground fault protection)
   h. The disconnect switch shall be UL Approved.
   i. Provide disconnect switch with heavy duty pistol handle and terminal lugs for 250 kcmil cables at line and load connections.

3. Soft Starter with By-Pass Contactor
   a. Type: Severe Duty Open type Multi-functional, Programmable, Reduced Voltage, Solid-State Motor Starter (Soft Starter).
   b. Frame Size: T
   c. Current Rating: 150 Amp
d. Operating Voltage: 200 - 600 Volt, 3 Phase, 60 Hertz

e. Maximum 3-Phase Horsepower Rating at 460V, 60Hertz and 1.15SF: 100hp

f. Ramp Time: 30 seconds

g. Adjustable Ramp Time Range: 0.5 – 180 seconds

h. Ramp Current: 450% of FLA

i. Starts per Hour: 4

j. Control Power: 24Vdc

k. Auxiliary Contacts: 1 Class A and 1 Class C rated for 120Vac, 3amp.

l. The Soft Starter shall be UL Listed.

m. Provide Soft Starter with built-in Run Bypass Contactor and terminal lugs for 500kcmil cables at line and load connections.

4. Control Power Transformer

a. Control power shall be 120 Vac obtained from integral control power transformer (CPT). Include control power transformer with adequate capacity to operate connected control, indication and protection devices, plus 100 percent spare capacity.

b. The dry-type CPT shall be 300 VA, 480 -120V, single phase, 60 Hertz.

c. Appropriately sized primary and secondary fuses shall be provided.

d. The primary side of the control power transformer shall be protected by current limiting fuses sized according to the requirement.

e. The secondary side of the control power transformer shall be fused appropriately to protect the transformer from overloads.

f. The standard control circuit shall have one leg of the secondary grounded.

5. DC Power Supply

a. Provide a 24Vdc power supply for the soft starter.

b. Input/Output: 115Vac input, 24Vdc output

c. Steady state wattage: As required, a minimum of 55W

d. Inrush wattage: 250W

e. The DC Power Supply shall be Cutler-Hammer Catalog Number PSS55A or approved equal.

6. Terminal Blocks for internal & external control, protection and instrumentation wiring
a. Terminal blocks shall be double-row collar type screw terminals with spring action overlapping top plates rated for 30 amperes, 600 volts with barrier strips between each adjacent row of terminal positions. Terminal blocks shall conform to NEMA ICS-4 and UL 50. Each terminal shall have a white marking strip and plastic cover.

b. Provide terminal blocks with sufficient terminal points for all required wiring interconnections.

c. Provide 25 percent spare terminals. Mount terminal blocks securely to bracket assembly with stainless steel screws and washers. Terminals shall be grouped and segregated for different operating voltages.

d. Verify that each terminal block is able to accommodate two 14 AWG wires.

7. Internal control, protection and instrumentation wiring.

   a. For the control wiring inside the controller enclosure use minimum 16 AWG, stranded, thermoplastic-insulated wire, rated 105 degrees C, with red color for ac.

8. Internal power interconnections

   a. Internal power interconnections shall be made with insulated bus-bars or insulated cable rated for motor FLA.

9. Provisions for external power wiring

   a. The controller Line and Load terminals arrangement shall allow adequate space for field termination of external power wiring.

PART 3 - EXECUTION

3.01 FABRICATION, ASSEMBLY AND TESTING

   A. The Controller shall be fabricated and fully assembled at the supplier’s plant.

   B. A shop test shall be performed and the test report approved prior to shipping to site. All devices, wiring and connections shall be functionally checked for proper operation in the manufacturing facility.

   C. The shop test shall include a full load test with the actual fan for which it is intended or a load of equivalent mechanical/electrical characteristics.

   D. The final shop test shall be witnessed by the Owner.

   E. All inspections and tests at the manufacturing facility shall be documented and signed by qualified staff at the manufacturing facility.

3.02 INSTALLATION

   A. Install individual motor controllers as indicated and as recommended by the manufacturer/supplier.

   B. Anchor equipment in accordance with the seismic requirements in Section 26 05 00, Common Work Results for Electrical.
C. Motor Data: Provide label on each motor controller enclosure door in accordance with Section 26 05 53, Identification for Electrical Systems, and as indicated on the Contract Drawings.

3.03 ENERGIZING MOTOR CONTROL CENTERS

A. Perform pre-energizing checkout procedure in accordance with NECA 402 prior to energizing the motor controller.

B. Notify Resident Engineer prior to energizing motor controller.

C. Energize motor controllers in accordance with NECA 402.

3.04 FIELD QUALITY CONTROL

A. Provide equipment and instruments and perform the following tests:

1. Test circuits for connections in accordance with accepted wiring diagrams.

2. Test that insulation resistance to ground of nongrounded conductor is a minimum of 10 megohms.

3. Test equipment enclosures for continuity to the grounding system.

4. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2 hour.

5. Demonstrate the specified controller operation to the satisfaction of the Resident Engineer.

3.05 DEMONSTRATION AND TRAINING:

A. Following installation, the Contractor shall make available the services of technician(s) to inspect the system installation and complete a thorough test and calibration of the system.

B. Contractor shall provide equipment demonstration and training for the Operation Engineer's maintenance personnel to adjust, operate, and maintain motor controllers, interlocking and controls, protective devices, instrumentation and accessories, and provide a minimum of 8 hours of training to the owner's personnel. A minimum of 3 full days shall be allowed for the completion of all start-up and training requirements.

END OF SECTION
SECTION 26 28 15
ENCLOSED SWITCHES AND FUSES

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing and installing enclosed switches and fuses.

1.02 REFERENCES
A. This Section incorporates by reference the latest revision of the following documents
   1. American National Standards Institute (ANSI):
      a. UL 198C High Interrupting-Capacity Fuses; Current-Limiting Types
      b. UL 198E Class R Fuses
   2. National Electrical Manufacturers Association (NEMA):
      a. NEMA KS 1 Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
      b. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: Submit manufacturers’ product data for specified equipment and materials. Include the following information for each item:
   1. Outline drawings with dimensions
   2. Equipment ratings for voltage, capacity, horsepower, and short circuit withstand.

PART 2 - PRODUCTS

2.01 MATERIALS
A. ENCLOSED SWITCHES
   1. Fusible Switch Assemblies: NEMA KS 1; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Suitable for Class R or J fuses with fuse rejection devices installed.
2. Nonfusible Switch Assemblies: NEMA KS 1; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

3. Enclosures: NEMA KS 1 as required for the environment or as designated on the Contract Drawings.
   a. Type:
      1) For dry and dust-free indoor location: NEMA 250, Type 1 with drip shield.
      2) For damp and dusty indoor location: NEMA 250, Type 12.
      3) For outdoor location: NEMA 250, Type 3R.
      4) For areas subject to corrosion: NEMA 250 Type 4X

4. Enclosures in escalator and elevator pits shall be rated NEMA 250 Type 12.

5. All equipment shall be rated for the available short circuit fault current.

B. FUSES
   1. Fuses, 600 Amperes or Less: UL 198C, Class J or UL 198E Class RK1 or as indicated on Contract Drawings. 600 V rated, one-time, time delay, current-limiting type.
   2. Fuse sizes shown on plans have been sized at the maximum NEC allowance for time delay fuses (175%). Fuse sizes can be reduced for coordination purposes if allowed for by mechanical equipment manufacturer. Wire size shall not be reduced under any circumstances.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Install disconnect switches where indicated on Contract Drawings with external handle centered 60 inches above finish floor or grade level.
   B. Install fuse-rejection devices in fuse clips if required.
   C. Install fuses in fusible disconnect switches.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 26 29 13
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing and installing individual motor starters, variable frequency drives, motor control centers, and lighting contactors.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 22 14 29, Sump Pumps and Controls
2. Section 23 73 13, Air Handler Unit
3. Section 25 08 00, Commissioning of Integrated Automation
4. Section 25 60 00, Building Management System (BMS)
5. Section 26 05 00, Common Work Results for Electrical
6. Section 26 05 53, Identification for Electrical System
7. Section 26 08 00, Commissioning of Electrical Systems

1.02 REFERENCES

A. This Section incorporates by reference the latest revision of the following documents

   a. ASTM A 653/A 653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   b. ASTM D 2092 Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting

2. Institute of Electrical and Electronics Engineers (IEEE):
   a. IEEE 344 Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

3. National Electrical Contractors Association (NECA):
   a. NECA 402 Recommended Practice for Installing and Maintaining Motor Control Centers

4. National Electrical Manufacturers Association (NEMA):
   a. NEMA ICS 2 Industrial Control Devices Controllers and Assemblies
b. NEMA ICS 6 Industrial Controls and Systems Enclosures

c. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Shop Drawings: Submit shop drawings and electrical diagrams. Identify relay characteristics, including inrush current rating, on shop drawings.

C. Coordination Drawings: Floor plans showing dimensioned layouts, required working clearances, and required area above and around enclosed controller and filter where pipe and ducts are prohibited. Show enclosed controller and filter layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Product Data: Submit manufacturer's product data of manufactured materials and equipment.

E. Calculations: For each type of harmonic filtering component. Include calculations indicating selection of filter for each application, including harmonic content before and after installation. Subsequent submittals shall also be provided following installation of selected components and field measurements in accordance with this specification to provide documentation of performance of each filter.

F. Load-current and list of settings of adjustable overload relays. Compile after motors have been installed and arrange to demonstrate DIP switch settings for motor running overload protection suitable for actual motor to be protected.

G. Operational and Maintenance Data: Submit maintenance data and operating instructions in accordance with Section 01 78 23, Operation and Maintenance Data, including the following requirements:

1. Description of the equipment and its components;

2. Manufacturer's operating and maintenance instructions, parts list, illustrations, and diagram of components;

3. Recommended list of spare parts; and

4. Wiring diagrams.

H. Test Reports: Submit certified test reports of factory and field tests performed, verifying that performance of equipment meets specification requirements.

I. Submit evidence of compliance to seismic safety requirements of the Washington State Building Code, local amendments thereto, and the National Electrical Code in conformance with Section 26 05 00, Common Work Results for Electrical.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage or distortion.

B. Store motor starters, control panels, and contactors in secure and dry storage facility.
PART 2 - PRODUCTS

2.01 MATERIALS

A. MOTOR STARTERS

1. Ensure motor starters meet the requirements of NEMA ICS 2, general purpose Class A, and the following additional requirements:

   a. Rating: Continuous current rating suitable for associated motor as indicated. Provide solid-state overload units sized for motor running protection based on duty rating and full-load current of supplied motor.


   a. Type, unless noted otherwise:
      1) For dry and dust-free indoor location: NEMA 250, Type 1 with drip shield.
      2) For damp and dusty indoor location: NEMA 250, Type 12.
      3) For outdoor location: NEMA 250, Type 3R.
      4) For areas subject to corrosion: NEMA 250 Type 4X


   c. Finish: Painted finish for all ferrous and galvanized metal surfaces.
      1) Prepare ferrous metal surfaces for painting in accordance with standard industry practice.
      2) Prepare galvanized metal surfaces for painting in accordance with ASTM D 2092.
      3) After pretreatment, prime-paint surfaces with an approved corrosion-inhibitive metal primer for ferrous or galvanized surfaces, as applicable.
      4) For the finish coat use a heavy-duty, industrial-grade polyurethane enamel.

3. Provide auxiliary devices at each contactor meeting the following requirements:

   a. Ensure auxiliary devices are manufacturer’s standard products. Ensure Control diagrams show actual configuration including auxiliary devices.

   b. Heavy-duty type relay: Select devices with a Contact rating of 20 A at 120 V ac which operate satisfactorily at 120 degrees F.

   c. Indicating pilot lights on each unit enclosure. De-energized: GREEN; and energized: RED.

   d. Control selector switch on each unit enclosure: HAND/OFF/AUTO.
4. Mount terminal blocks used at the contactor in the enclosure. Verify that each terminal block is able to accommodate two 14 AWG wires.

5. Wiring, unless noted otherwise:
   a. For the control wiring inside the contactor enclosure use minimum 16 AWG, stranded, thermoplastic-insulated wire, rated 221 degrees F, with red color for ac.
   b. Use power cable of the same type and rating as control wiring, black color, and with capacity compatible with the contactor or breaker rating.

6. Manual Starters: Quick-make quick-break toggle mechanism, trip-free manual reset thermal overload relay, position indicator showing ON, OFF, and TRIPPED positions, and red indicating light showing the CLOSED position.

   a. 480 V primary to 120 V secondary control transformer with minimum one fuse in the secondary circuit.
   b. Two NO and two NC auxiliary contacts with provision for addition of two NO or NC contacts.

8. Combination Motor Starters: Rated 480 V, three phase or single phase, 60 Hz. Meet the requirements for magnetic motor starters with the following additional requirements:
   a. Provide one 480 V, three-pole, motor circuit protector type circuit breaker with current limiter, as indicated, with adjustable trip-point.
   b. Provide externally mounted operating handle with position indicator showing ON, OFF, or TRIPPED condition of the circuit breaker or disconnect switch as applicable. Install operating handle that is interlocked to prevent opening and closing of the door when the circuit breaker or disconnect switch is in the ON position. Provide defeater to bypass the interlock.

B. Solid-State, Reduced Voltage Controller

1. NEMA ICS 2, suitable for use with NEMA MG-1, Design B, polyphase, induction motors. Sized as required for application(s) shown on Plans.

2. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.

3. Surge suppressor in Solid-State power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

4. Integral Current Transformer (CT) in each phase.

5. LED indicators showing motor and control status, including the following conditions:
   a. Motor Stopped.
b. Motor Starting.
c. Motor Stopping.
d. Motor at Speed.
e. Motor Alarm.
f. Controller Fault.

6. Integral mechanical run contactor operating automatically when motor reaches full speed.

7. Programmable Auxiliary Contacts, electro-magnetic one-pole relay, minimum 4, programmable normally open (N.O.) or normally closed (N.C.), selectable as:
   a. Normal.
   b. Up-to-Speed.
   c. External Bypass.
   d. Controller Fault.
   e. Motor Alarm.

8. Open-Style design suitable for mounting in separately provided enclosure.

C. Variable Frequency Drives (VFD)

1. 1-1/2 HP to 30 HP motors, as indicated in Plans, shall be equipped with 6-pulse, space vector sine-coded Pulse Width Modulated (PWM) adjustable frequency controllers, supplied as enclosed units. Listed and labeled as a complete unit to provide variable speed of a NEMA MG-1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.

2. Controllers shall be coordinated with the motors supplied for proper operation and features.
   a. Output rating: 460 Volts, 3-phase, 6 to 60 Hz, with voltage proportional to frequency throughout the voltage range.
   b. Starting Torque: 100 percent of rated torque, or as indicated.
   c. Speed regulation: Plus or minus 3 percent.
   d. Ambient temperature: 0 to 40 deg. C.
   e. Efficiency: 98 percent, minimum, at full load and 60 Hz.
   f. Minimum Displacement Power Factor at input terminals: 95 percent.
   g. Isolated control interface to allow controller to follow control signal over a 40:1 speed range: 4 to 20 mA at 24 VDC.
   h. Internal adjustability: Provide the following internal adjustment capabilities:
      1) Acceleration: 1 to 3200 seconds.
2) Deceleration: 1 to 3200 seconds.
3) Current Limit: 50 to 120 percent of maximum rating.

i. Self-protection and reliability features shall include the following:
   1) Input transient protection by means of surge suppressors.
   2) Snubber networks to protect against malfunction due to system voltage transients.
   3) Motor overload relay: Adjustable and capable of NEMA 250, Class 10 performance.
   4) Notch filter to prevent operation of the drive-motor-load combination at a natural frequency of the combination.
   5) Loss of phase protection.
   6) Reverse phase protection.
   7) Under- and Overvoltage trips.
   8) Overtemperature trip.
   9) Short-circuit protection.

3. Input circuit breakers, interlocked with the enclosure door, with through-the-door handle to provide positive disconnect of incoming AC power. The circuit breaker shall be rated for 42,000 AIC.

4. A door-mounted keypad with integral LCD display shall be provided, capable of controlling the VFD as well as displaying and setting control parameters. Control functions shall include Start-Stop and Auto-Manual selection, with manual speed control potentiometer and elapsed run time meter.

5. Door mounted LED indicators shall be provided to indicate the following conditions:
   a. Power On.
   b. Drive Running.
   c. Overvoltage.
   d. Line Fault.
   e. Overcurrent.
   f. External Fault.

6. VFD shall include comprehensive microprocessor based diagnostic capabilities that monitor drive control functions and display faults and operating conditions. Drive shall maintain a time and date stamped fault log for the 64 most recent events which can be accessed through the keypad to display the event information in English, not fault codes.
7. Flash Protection Labeling: Variable frequency drives shall be marked to warn qualified personnel of potential arc flash hazards. The markings shall be located so as to be clearly visible before examination, adjustment, servicing, or maintenance of the equipment.

8. VFDs shall meet all requirements, as outlined in the current edition of IEEE 519, for each individual and total harmonic voltage and current distortion and as indicated in this specification. Individual or simultaneous operation of the VFDs shall not add more than 3% total harmonic voltage distortion while operating at full load and speed from the utility source. If harmonic filters are required to meet these requirements, the VFD manufacturer must provide, as a minimum, 5th, 7th, and 11th harmonic filters and is responsible for the design and manufacture of these filters. Any required filters shall be provided with a separate contactor such that the VFD can operate in the event of a filter failure. Failure of a filter shall not cause the entire drive system to shut down.

9. Harmonic compliance shall be verified with on-site field measurements of both the voltage and current harmonic distortion at the controller input terminals with and without the VFD operating. A recording type Fluke 41 or equivalent, harmonic analyzer displaying individual and total harmonic currents and voltages must be used.

10. Spare Parts:
   a. Fuses: Three for each type installed.
   b. Indicating Lamps: Five of each type installed.
   c. Converter Power Semiconductor: Two of each type installed.
   d. Inverter Power Semiconductor: Two of each type installed.
   e. Gate Firing Boards: One of each type installed.
   f. Keypad Assembly: One of each type installed.
   g. Ventilation Filters: Two for each controller shipped.

D. Motor Circuit Protectors
   1. Magnetic only short-circuit protection, with visible trip indication, suitable for use as motor branch circuit disconnect.
   2. Sized as appropriate for motor load served.

E. Pump Controller Panels
   1. Provide industrial enclosures, NEMA 250 Type 4X, for control of track drainage and sanitary pump stations.
   2. Provide Solid-State Reduced Voltage motor controllers.
   3. Power Distribution Blocks: Provide distribution blocks rated 600 V AC, 350A, with lugs suitable for use with 75 °C conductors. Three-phase blocks, with main lugs, 2 per phase, sized for maximum #2/0 AWG, branch lugs, 6 per phase, sized for maximum #2 AWG.
4. Terminal Blocks: Provide DIN rail mounted, impact and combustion resistant, self-extinguishing type terminal blocks. Terminal blocks shall be rated, as a minimum, for continuous operation at 10 A AC at 600 V AC. Terminals shall be of the tubular screw clamp type and shall be capable of accommodating two #14 AWG or one #12 AWG conductors of the type specified herein. Furnish all required end plates, channel clamps, separators and other components required for installation in accordance with the manufacturer's recommendations. Terminal blocks shall each be equipped with an appropriate label which is large enough to legibly accommodate identifying numbers as shown on the Plans.

5. Wireway: Provide slotted type plastic wireways, with covers, of the size specified in the Plans and as required for neat installation of interconnecting conductors. Wireways shall be restricted slot type to prevent accidental removal of wires and shall be constructed of rigid, non-flammable polyvinyl chloride (PVC). Wireway shall be UL recognized for continuous operation at 120 °F.

6. Pilot Lights: Provide industrial duty, 22mm (7/8") body, round dome lens, L.E.D. type pilot lights. Units shall be rated NEMA Type 13, oil tight as defined by NEMA 250 and shall operate at 24 V DC primary supply voltage. Lens color shall be as indicated in the Plans.

7. Selector Switches: Provide industrial duty, 22mm (7/8") body, selector switch units with stackable, replaceable contact blocks. Units shall possess the number and type of contacts indicated on the Plans and shall be rated NEMA Type 13, oil tight. Operator units shall be maintained or spring return with the number of positions as indicated in the Plans. Keylocked switches shall possess identical cylinder locks employing the same master key and shall hold the key captive in the positions indicated as operational positions. All selector switch unit contacts shall be rated for continuous operation at 10 A at 120 V AC.

8. Digital Panel Meters: Provide an industrial duty, 4-1/2 digit, DC, digital panel meter with minimum numeral height of 0.5 inches. Numeral display shall be red or blue L.E.D. type. Meter shall accept a 4 to 20 mA DC input signal and operate at 120 V AC supply voltage. Panel meter shall be field scalable, accurate to ± 0.5 %, and shall be calibrated for the range indicated on the Plans. Meter front shall be gasketed and shall be rated NEMA Type 4 when installed in a panel. Wiring connections shall be via screw type terminal blocks. Digital Panel Meters shall provide local indication of sump level.

9. Control Relays: Control relays shall have 24 V DC coils, DIN rail mounted 14-spade square base, and shall be equipped with four independent double-throw contacts rated for continuous operation at 10 Amperes (A), at 120 V AC, with a resistive load. Relays shall be equipped with neon internal pilot lights to indicate coil energization, and shall be rated for operation over the temperature range of -30°F to +110°F. Contact ratings specified herein are minimum allowable values.

10. Enclosure Temperature Transmitter: Provide an industrial duty, DIN rail mounted, Resistance Temperature Device (RTD) type transmitter. Transmitter shall be loop powered, 24 V DC, and shall accept as input a 100 Ohm Platinum, 2-wire RTD. Output shall be 4 to 20 mA DC, calibrated to provide a full-scale output signal over the range 0 °F to 220 °F. Provide surface mounted 100 Ohm Platinum RTD sensor in enclosure interior space.

11. Pump Monitoring Units: Provided under Section 22 14 29 Sump Pumps and Controls.

12. Control Power Transformers:
a. Primary Voltage: 480 V AC.

b. Secondary Voltage: 120 V AC.
   1) VA as required to supply control devices shown on Plans.

c. Secondary Voltage: 24 V AC.
   1) VA as required for pump monitoring units provided under Section 22 14 29 Sump Pumps and Controls.

13. Automatic pump station control is performed by the Building Management System (BMS) specified in Section 25 60 00, Building Management System (BMS)

F. Lighting Contactors

1. Contactors: NEMA ICS 2; electrically-held, two-wire control.

2. Coil Operating Voltage: 24 Volts DC.

3. Contacts: Silver alloy, fully rated for tungsten lighting loads, 20A, 600 volts or as noted on Contract Drawings.

4. Enclosure: NEMA 250, Type 12. Open-type contactors may be used when mounted within equipment enclosures as a listed assembly.

5. Provide screw-terminals for termination of circuit conductors unless shown otherwise on Contract Drawings.

G. Lighting Control Panels

1. Provide industrial enclosure, NEMA 250 Type 12, for control of lighting systems. Ensure the control panel includes electrically-held lighting contactors as specified herein and ancillary equipment including terminal blocks, DC power supplies, control relays, selector switches, and pilot lights.
   a. Ancillary equipment and components shall comply with the requirements specified herein for Pump Controller Panels.
   b. Ensure control panel has the capability to manually override automatic contactor control.

2. Provide accessory equipment including low-voltage control power supply transformer, interposing feedback relays, and terminal strips for interface with field wiring.

3. 24VDC Power Supplies: Provide 5A, regulated 24 volt DC power supply in each enclosure.

4. Provide the following automatic and remote functions in the lighting control panel
   a. Provide a three-position selector switch in the controller front cover to bypass normal automatic operation and turn on or off all associated lighting circuits.
b. Automatic lighting control is performed by the Building Management System (BMS) specified in Section 25 60 00, Building Management System (BMS).

PART 3 - EXECUTION

3.01 INSTALLATION

A. Size requirements

1. Motor starters shall not be smaller than size 1 for 480 V and size 0 for 120, 208 or 240 V ac.

2. For fractional horsepower loads rated at 120 V ac, single phase provide manual starters.

B. Install individual motor starters and contactors as indicated and as recommended by the manufacturer.

C. Install motor control centers as recommended by the manufacturer and in accordance with NECA 402.

D. Anchor equipment in accordance with the seismic requirements in Section 26 05 00, Common Work Results for Electrical.

E. Select and install heater elements in motor starters to match installed motor characteristics.

F. Motor Data: Provide label on each motor starter enclosure door in accordance with Section 26 05 53, Identification for Electrical Systems.

G. Install lighting contactors and lighting control panels in accordance with Contract Drawings and make field connections to remote switches and pilot devices.

H. ENERGIZING MOTOR CONTROL CENTERS

1. Perform pre-energizing checkout procedure in accordance with NECA 402 prior to energizing motor control centers.

2. Notify Resident Engineer prior to energizing motor control centers.

3. Energize motor control centers in accordance with NECA 402.

3.02 FIELD QUALITY CONTROL

A. Provide equipment and instruments and perform the following tests:

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.

2. Test circuits for connections in accordance with accepted wiring diagrams.

3. Test that insulation resistance to ground of nongrounded conductor is a minimum of 10 mega ohms.

4. Test equipment enclosures for continuity to the grounding system.
5. Test operation of circuits and controls. When testing, operate each control a minimum of ten times and each circuit continuously for a minimum of 1/2 hour.

6. Connect a recording harmonics meter to each power bus from which VFDs are fed. Record harmonics from 50% to full load operation of connected VFDs.

7. All commissioning procedures and requirements outlined in Section 26 08 00, Commissioning of Electrical Systems, and Section 25 08 00, Commissioning of Integrated Automation.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This section includes specifications for three-phase, on-line, static-type, uninterruptible power supply (UPS), complete with transient voltage surge suppression, input harmonics reduction, rectifier-charger, battery, battery disconnect device, inverter, static bypass transfer switch and maintenance bypass/isolation switch.

B. Related sections: the work of the following sections is related to the work of this section. Other sections, not referenced below, may also be related to the proper performance of this work.

1. Section 25 08 00, Commissioning of Integrated Automation
2. Section 26 05 26, Grounding and Bonding for Electrical Systems
3. Section 26 05 53, Identification for Electrical Systems
4. Section 26 08 00, Commissioning of Electrical Systems

1.02 REFERENCES AND STANDARDS

A. This Section incorporates by reference the latest revision of the following documents.

B. Applicable provisions of the following standards applies to the work of this Section, except as modified herein, and are hereby made a part of these Specifications to the extent required:

1. American National Standards Institute (ANSI):

2. National Electrical Manufacturers Association (NEMA):
   b. NEMA 250: Enclosure for Electrical Equipment.

3. Underwriters Laboratories Inc. (UL):
   a. UL 1778: Uninterruptible Power Supply Equipment.


5. Institute of Electrical and Electronic Engineers (IEEE):


7. Federal Communications Commission (FCC):
   a. FCC Part 15 Class A.

8. National Institute of Standards and Technology (NIST)

1.03 DEFINITIONS

A. EMI: Electromagnetic interference.

B. LCD: Liquid-crystal display.

C. LED: Light-emitting diode.

D. THD: Total harmonic distortion.

E. UPS: Uninterruptible power supply.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Furnish the following:

1. Product Data: Include data on features, components, ratings, and performance for each uninterruptible power supply component indicated.

2. Shop Drawings: Detail assemblies of equipment indicating dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.

3. Wiring Diagram: Detail internal and interconnecting wiring, power, signal, and control wiring. Differentiate between field-installed and factory-installed wiring and components.

4. Dimensioned Outline Drawings of Equipment Unit: Identify weight and center of gravity and locate and describe mounting and anchorage provisions for each individual cabinet or enclosure.

5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

6. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

7. Qualification Data: For firms and persons specified in “Quality Assurance” Article.

8. Factory Test Reports: Comply with specified requirements.
9. Field Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

10. Maintenance Data: For maintenance manuals specified in Division 1, General Requirements, include the following:
   a. List of spare parts and replacement components recommended being stored at project site for ready access.
   b. Detailed operating instructions covering operation under both normal and abnormal conditions.
   c. Warranties: Special warranties specified in this Section.

11. Manufacturer Seismic Qualification Certification: Submit certification that UPS equipment will withstand seismic forces in accordance with Uniform Building Code (UBC) for Washington State seismic zone three requirements.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain the UPS and associated components specified in this Section from a single manufacturer with responsibility for entire UPS installation.

B. The supplier has a local service organization with factory-trained technicians and a local part inventory, and is capable of providing training, parts and emergency maintenance and repairs for equipment at the Contract site with 8 hours maximum response time.

C. Installer Qualifications: An experienced installer who is an authorized representative of UPS manufacturer for both installation and maintenance of units required for this Contract for at least 5 years.

D. Listing and Labeling: Provide electrical components, devices, and accessories that are Listed and Labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Authority Having Jurisdiction, and marked for intended use for the location and environment in which they are installed. The equipment is labeled “Suitable for use on emergency system” in accordance with NEC 700-3.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.

B. Store equipment in spaces with environments controlled within manufacturer’s ambient temperature and humidity tolerances for non-operating equipment.

1.07 PROJECT CONDITIONS

A. Environmental Conditions: UPS is capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Electronic Components: 32 to 104 degrees F.

2. Ambient Temperature for Battery: 41 to 104 degrees F.

3. Relative Humidity: 5 percent to 95 percent, noncondensing.
4. Altitude: Sea level to 500 feet.

1.08 WARRANTY

A. Warranties, General: Special warranties specified in this Article is in addition to, and run concurrent with, other warranties made under requirements of these Specifications.

B. Special Battery Warranties: Written warranty, signed by manufacturer and Installer agreeing to replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

C. Warranted Cycle Life for Sealed Lead-Acid Batteries: Equal to or greater than that represented in manufacturer’s published table based on annual average battery temperature of 77 degrees F.

D. Special UPS Warranties: Written warranties, signed by manufacturer and Installer agreeing to replace components that fail in materials or workmanship within special warranty period.

E. Special Warranty Period: two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. SolidState controls Inc.
2. Powerware.
3. Liebert Corp.
4. Controlled Power Company
5. Approved Equal

2.02 MANUFACTURED UNITS

A. Output Load Capacity: 1) Three Phase, 0.8 lagging power factor. 2) Single Phase, 0.8 lagging power factor. Refer to the Contract Drawings for the UPS ratings (voltage and KVA).

B. UPS will perform as specified in this Article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of five percent of the fundamental value.

5. Output Frequency: 60 Hz plus/minus 0.5 percent over full range of input voltage, load and battery voltage.

6. Load is 50 percent unbalanced continuously.

C. Minimum Duration of Supply: If battery is sole energy source supplying UPS-rated full-output load current at 80 percent power factor, duration of supply is 90 minutes.

D. Input Voltage Tolerance: System steady state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 20 percent from nominal voltage.

E. Maximum Acoustical Noise: 65 dBA measured one meter from the surface of the UPS.

F. Maximum Energizing Inrush Current: Six times the full-load current.

G. Maximum AC Output-Voltage Regulation for Loads up to 50 percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

H. Output Frequency: 60Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

I. Maximum Harmonic Content of Output-Voltage Waveform: Five percent RMS total and three percent RMS for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

J. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of full-load rating for 10 minutes without bypass source, and 150 percent for 30 seconds without bypass source.

K. Input Power Factor: A minimum of 0.85 lagging when supply voltage and current are at nominal rated values and UPS is supplying rated full-load current.

L. EMI Emissions: Comply with FCC Rules and Regulations, 47 CFR 15 for Class A

M. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

N. Enclosure: Comply with NEMA 250, Type 1, unless otherwise indicated.
   1. The cabinet doors and louvers require tools for access.
   2. Provide casters and leveling feet.
   3. Front access only for servicing.
   4. The overall enclosure width and depth will not exceed the space allocated on the Contract Drawings.

O. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

P. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect, static bypass transfer switch, and
maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41, Category B.

2. Additional Surge Protection: Protect internal UPS components from low frequency, high-energy voltage surges described in IEEE C62.41. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.

Q. Seismic-Restraint Design: UPS assemblies, subassemblies, and components; and fastenings and supports, mounting, and anchorage devices for them, are designed and fabricated to withstand static and seismic zone three forces in all directions.

R. UPS Cabinet Ventilation: Cooling of the UPS is by forced air. Low-velocity fans are used to minimize audible noise output. Fan power is provided by the UPS output. UPS cabinet ventilation shall be in compliance with the Seattle Mechanical Code Section 502.5.

S. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 2.0, minimum.

T. Capacity Upgrade Capability

1. Selected systems shall be capable to accept a field installed power upgrade to the next higher power rating without an increase in cabinet size.

2. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

U. Extra Materials

1. Local field service organization shall stock extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

2. Provide qualified service personnel available around-the-clock 365 days a year.

3. Provide toll free direct phone number.

4. Fuses: One for every ten of each type and rating, but not less than one of each.

5. Cabinet Ventilation Filters: One complete set.

6. One spare circuit board for each critical circuit.

2.03 COMPONENTS

A. Rectifier-Charger

1. Capacity: Adequate to supply the inverter during full-rated output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within ten times the rated discharge time for duration of supply under battery power at full load.
2. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

3. Rectifier-Charger Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
   a. Response Time: Field adjustable for maximum compatibility with portable generator-set power source.

4. Battery Float-Charging Conditions: Comply with battery manufacturer written instructions for battery terminal voltage and charging current required for maximum battery life.

B. Inverter
1. Description: Pulse-width modulated, with sinusoidal output.

2. Description: Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with portable engine-generator-set power source.

C. Static Bypass Transfer Switch
1. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

2. Switch Rating: Continuous duty at the rated full-load current of the UPS, minimum.

D. Battery
1. Description: Sealed, valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, and complete with battery disconnect switch.

E. UPS Control and Indication
1. Provide system power flow diagram on front of cabinet.

2. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

3. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include an audible signal and a visual display.

4. Indications: Plain-language messages on a digital LCD or LED.

5. Dry-form “C” contacts are available for remote indication of the following conditions:
   a. UPS on battery.
   b. UPS on-line.
   c. UPS load-on bypass.
   d. UPS in alarm condition.
e. UPS off (maintenance bypass closed).

F. Maintenance Bypass/Isolation Switch

1. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
   a. Switch are interlocked to prevent interrupting power to the load when switching to the bypass mode.
   b. Switch shall isolate other UPS components electrically to permit safe servicing.

2. Comply with NEMA PB 2 “Dead-Front Distribution Switchboards” and UL 891 “Dead-Front Switchboards”.

3. Switch Rating: Continuous duty at rated full-load current of UPS.

4. Mounting Provision: Internal to system cabinet or external wall mount.

5. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by static bypass transfer switch. Lock is designed specifically for electrical component interlocking.

G. Monitoring by Remote Computer

1. Description: Communication module in unit control panel would provide capability for remote monitoring of status, parameters, and alarms. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
   a. LON Mark compatible network interface units, or Approved Equal.
   b. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Design for Microsoft Windows or approved equal application in an IBM-compatible computer, which is not included in this Section.

H. Basic Battery Monitoring

1. Battery Ground-Fault Detector: Initiates visual and audible alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

2. Battery compartment smoke/high-temperature detector initiates a visual and audible alarm when smoke or a temperature greater than 75 degrees C occurs within the compartment.

3. Annunciation of Alarms: At UPS control panel.

I. Additional Battery Monitoring

1. Monitoring features and components include the following:
a. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors. Provide fuses as required for proper protection of conductors.

2. Functional Performance: Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events record measurements timed to the nearest second. Include measurements of the following parameters:
   a. Total battery voltage and ambient temperature;
   b. Individual cell voltage, impedance, and temperature; Measure battery and cell voltages and time to the nearest second during battery discharging events such as utility outages;
   c. Individual cell electrolyte levels.

**J. Battery Cycle Warranty Monitoring**

1. **Description:** Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by a life-cycle warranty.

2. **Basic functional Performance:** Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral LCD.

3. Additional monitoring functions and features include the following:
   a. Measuring and Recording: Total voltage at battery terminals, providing alarm for excursions outside the proper float voltage level.
   b. Monitors: Ambient temperature at battery and initiates an alarm if temperature deviates from normally acceptable range.
   c. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
   d. Alarm Contacts: Arranged to provide local alarm for abnormal temperature, abnormal battery voltage, or temperature.
   e. Memory: Device stores recorded data in nonvolatile electronic memory.
   f. RS-232 Port: Permits downloading data to a portable personal computer.
   g. Modem: Makes measurements and recorded data accessible to remote personal computer via telephone line. Computer is not specified in this Section.

### 2.04 SOURCE QUALITY CONTROL

**A.** Factory test complete UPS, including battery, before shipment. Include the following tests:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days advance notice of test and provide opportunity for Resident Engineer to observe tests.

C. Report test results. Include the following data:
   1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
   2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.

D. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.01 EXAMINATION
   A. Examine elements and surfaces to receive equipment for compliance with installation tolerances and other conditions affecting performance, including, but not limited to, ambient temperature, cooling air circulation, contaminants and disassembly and maintenance space.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION
   A. Install system components on concrete floor. Cast-in-place concrete, reinforcing, and formwork are specified in Division 03, Concrete.
   B. Maintain minimum clearances and workspace at equipment according to manufacture’s written instructions and NFPA 70.
   C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer’s wiring diagrams, unless otherwise indicated.
   D. GROUNDING
      1. Comply with Section 26 05 26, Grounding and Bonding for Electrical Systems, for materials and installation requirements.
      2. Comply with NFPA 70 for grounding and bonding requirements for Separately Derived Systems.
   E. IDENTIFICATION
      1. Identify components and wiring according to Section 26 05 53, Identification for Electrical Systems.
2. Equipment is labeled “Suitable for use on emergency systems” in accordance with NEC 700-3.

3. Instructional signs: Install approved legend where instructions or explanations are required for system of equipment operation.

F. BATTERY EQUALIZATION

1. Equalize charging of battery cells according to manufacturer’s written instructions. Record individual-cell voltages.

3.03 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage the services of a factory-authorized service representative to supervise UPS installation, startup, and preliminary testing and adjustment and to participate in final tests, inspections, and adjustments.

B. Electrical Tests and Inspections: Perform tests and inspections according to manufacturer’s written instructions and as listed below to demonstrate condition and performance of each component of the UPS:

1. Comply with requirements of Section 25 08 00, Commissioning of Integrated Automation

2. Comply with requirement of Section 26 08 00. Commissioning of Electrical Systems

3. Inspect interiors of enclosures, including the following:

   a. Integrity of mechanical and electrical connections.

   b. Component type and labeling verification.

   c. Ratings of installed components.

4. Test manual and automatic operational features and system protective and alarm functions.

5. Test communication of status and alarms to remote monitoring equipment.

6. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the unit’s rating. Use instruments calibrated, within the previous 6 months according to National Institute of Standards and Technology (NIST) standards.

   a. Simulate malfunctions to verify protective device operation.

   b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.

   c. Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.

   d. Test output voltage under specified transient-load conditions.

   e. Test efficiency at 50, 75, and 100 percent rated loads.

   f. Test remote status and alarm panel functions.
g. Test battery-monitoring system functions.

h. Test resistance to ground of battery negative pole.

C. Seismic-restraint inspections include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.

2. Test mounting and anchorage devices.

3. Verify batteries are properly mounted and secured to battery racks.

D. Correct deficiencies until specified requirements are met.

E. Record of Inspections: Maintain and submit documentation of inspections, including references to manufacturers written instructions and inspection criteria. Include results of inspections.

3.04 CONSTRUCTION

A. Sequence Of Operations

1. Automatic operation includes the following:

   a. Normal Conditions: Supply the load with ac power flowing from the normal ac power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.

   b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter ac power output to the load without switching or disturbance.

   c. If normal power fails, energy supplied by the battery through the inverter continues to supply-regulated ac power to the load without switching or disturbance.

   d. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.

   e. If battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to a float-charge mode.

   f. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption of supply.

   g. If a fault occurs in the system supplied by the UPS and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
h. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.

i. If battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

2. Manual operation includes the following:
   a. Turning the inverter off causes the load to be transferred by the static bypass transfer switch directly to the normal ac supply circuit without disturbance or interruption.
   b. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

3. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in the bypass mode. Device provides manual selection between the following three conditions without interrupting supply to the load during switching:
   a. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS AC input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
   b. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
   c. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and UPS rectifier-charger and inverter, or the battery and the inverter.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Sound Transit maintenance personnel to adjust, operate, and maintain the UPS.

B. Train Sound Transit maintenance personnel in the procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.

C. Review data in maintenance manuals. Refer to Section 01 78 23, Operation and Maintenance Data.

D. Schedule training with Resident Engineer with at least 7 days advance notice.

E. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period.
   1. Schedule monitoring and testing activity with Resident Engineer. Provide at least 7 days advance notice.
   2. Schedule monitoring and testing after substantial Completion, when UPS in supplying power to its intended load.

F. Monitoring and Testing Instruments: Three-phase, recording power monitors. Instruments provide continuous simultaneous monitoring of electrical parameters at input terminals of the UPS and at input terminals of a load served by the UPS. Instruments
would monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments are capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage impulses, phase-to-phase, phase-to-neutral, phase-to-ground, and neutral-to-ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.

G. Monitoring and Testing Procedure:

1. Exploratory Period: For the first 2 days, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these preliminary measurements with the objective of identifying optimum UPS, power system, load, and instrumentation set-up conditions for subsequent test and monitoring operations.

2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.
   a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS with respect to values specified in Part 2 of this Section, and to highlight any need to adjust, repair, or modify the UPS or any distribution system or load component that may influence its performance or that may require better power quality.
   b. Perform load and UPS power source switching and operate the UPS on generator power during portions of the test period.
   c. Operate the UPS and UPS loads in each mode of operation permitted by UPS controls and by the power distribution system design.
   d. Create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients that can be performed using loads and devices available as part of the facility's installed systems and equipment. Maintain normal operating loads in operation on system to maximum extent possible during tests.
e. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

H. Correlation with Specified UPS Monitoring Functions: Obtain printout recordings of built-in monitoring functions specified for UPS and UPS components in this Section that are simultaneous with those made with portable instruments in this Article.

1. Provide the temporary use of an appropriate personal computer and printer equipped with required connections and software for recording and printing if such units are not available on-site.

2. Correlate printouts with recordings for monitoring performed according to this Article; resolve and report anomalies in and discrepancies between the two sets of records.

I. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Correlate simultaneous recordings made on UPS input and load circuits.

J. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in final report:

1. Description of corrective actions performed during monitoring and survey work and their results;

2. Recommendations for further action to provide optimum performance by the UPS;

3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents;

4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations;

5. Recommendations for operating, adjusting, or revising UPS controls;

6. Recommendation for alterations to the UPS installation;

7. Recommendation for adjusting or revising generator-set or automatic transfer switch installations or their controls;

8. Recommendations for power distribution system revisions;

9. Recommendations for adjusting or revising electrical loads, or their connections or controls.

K. Interim and Final Reports: Provide an interim report at the end of each test period and final comprehensive report at the end of the final test and analysis period.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing, installing, testing, and commissioning interior and exterior Transit Station luminaries, illuminated exit signs, and their associated lamps, ballasts, poles, mounting hardware and accessories.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 33 00, Submittal Procedures
2. Section 25 60 00, BMS
3. Section 25 65 00 BMS Fiber I/O Network
4. Section 26 05 00, Common Work Results for Electrical
5. Section 26 05 25, Wire and Cable
6. Section 26 05 26, Grounding and Bonding for Electrical Systems
7. Section 26 05 33, Raceway and Boxes for Electrical Systems
8. Section 26 05 43, Underground Ducts and Raceways for Electrical Systems
9. Section 26 05 33, Identification of Electrical Systems
10. Section 26 08 00, Commissioning of Electrical Systems
11. Section 26 28 15 Enclosed Switches and Fuses
12. Section 26 29 13, Enclosed Controllers

1.02 REFERENCES

A. The publications listed below form a part of these Specifications to the extent referenced. The publications are referred to in the text by designation only. In case of conflict between provisions of these publications and the Contract Documents, the more stringent requirements shall apply.

1. AASHTO – American Association of State Highway and Transportation Officials

   a. ANSI C62.41 Surge Voltages in Low-Voltage Ac Power Circuits
b. ANSI C78.380 Electric Lamps – High Intensity Discharge Lamps, Method of Designation

c. ANSI C81.62 Lampholders for Electric Lamps

d. ANSI C82.4 Ballasts for High-Intensity-Discharge and Low Pressure Sodium Lamps (Multiple-Supply Type)

   b. ASTM A 167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
   c. ASTM A 366/A 366M Standard Specification for Commercial Steel (CS) Sheet, Carbon, (0.15 Maximum Percent) Cold-Rolled

4. Illuminating Engineering Society of North America (IES):
   a. IES Lighting Handbook, Reference and Application

5. National Electrical Contractors Association (NECA):
   a. NECA/IESNA 502 Recommended Practice for Installing Industrial Lighting Systems

   a. NFPA 70 National Electrical Code
   c. NFPA 130 Fixed Guideway Transit And Passenger Rail Systems

7. Porcelain Enamel Institute (PEI):
   a. PEI-1001 Specifications for Architectural Porcelain Enamel

8. U.S. Environmental Protection Agency (EPA):
   a. 22 CCR Section 66260.200 (e) Toxic Characteristic Leaching Procedure (TCLP).

1.03 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures.

B. Luminaire Product Data Manual: Submit luminaire data manual documenting that luminaires, ballast and lamps fully comply with contract documents and indicating luminaire construction, photometric performance, installation, and maintenance requirements. Include the following information and exhibits:

1. Include in the manual a cover, title page, and table of contents. Verify that the cover and title page identify the document, project, client, Contract name, number and date of issuance. Ensure that the table of contents provides, at a glance, the overall document scope and structure and, as a minimum, a heading
for each luminaire type with each grouping prefaced by a "general information" report sheet.

2. Ensure manual contents are prepared by the authorized manufacturer’s representative serving the project area and include clear and legible product specifications, drawings and illustrations of sufficient detail to describe the following:

   a. Luminaire housing, hardware, and finishes;
   
   b. Light controlling elements;
   
   c. Electrical components, including lampholders, ballast, and provision for conduit entry; and
   
   d. Support details including foundation. Indicate weight of luminaire, complete with lamps.

3. Ensure the manual includes procedures for installation of the complete lighting unit in its final service location. Provide dimensions to locations of openings and parts interfacing with remote systems, such as mounting hardware, auxiliary electrical equipment, lighting control equipment, and lamps.

4. Provide photometric reports from an independent, certified testing laboratory for each luminaire type where required by the luminaire schedule.

5. Ensure the manual includes operation and maintenance requirements in accordance with Section 01 78 23, Operation and Maintenance Data, and the following information:

   a. Materials and components clearly indicated in the parts list;
   
   b. Relamping methods;
   
   c. Special tools required; and
   
   d. Frequency of inspection, tightening, or other service recommended for preventative maintenance.

6. Include within the submittals a list of manufacturer’s representatives (including mailing address, e-mail address, and telephone and fax numbers) identifying which luminaire types they represent.

7. Provide templates for mounting of light poles. Provide dimensions to locations of openings and parts interfacing with remote systems, such as pole bases, mounting hardware, auxiliary electrical equipment, and lamps.

8. Provide calculations indicating capability of light poles with luminaires installed to withstand wind load requirements. Proper selection of anchor bolts shall be included in the computation.

C. Test Reports: Submit test reports of factory and field tests performed, in accordance with applicable referenced standards and specification requirements. Report test data on 8-1/2 by 11-inch sheets and certified by a nationally recognized independent testing laboratory.

D. Samples: Submit one complete luminaire of each type indicated on Contract Drawings. Each sample requires the Resident Engineer's approval and, once submitted, become
the property of Sound Transit. Approved samples will become the Resident Engineer's control samples. Provide samples complete with all housing and trim components in color specified, support accessories, 120 V ballast, and wired to an eight-foot power cord terminated with standard 120 V grounding cord cap.

1.04 DELIVERY, HANDLING, AND STORAGE

A. Handle and transport products in a manner that prevents damage.
B. Wrap and package products to avoid damage.
C. Indelibly mark each carton with minimum 1/2-inch high letters containing the following information:
   1. Luminaire, lamp, or component type.
   2. Quantity.
   3. Manufacturer's name and product number.
D. Store products in a clean, dry, and secure storage area pending installation.

1.05 EXTRA STOCK

A. Lamps: 10 percent of quantity furnished, minimum of two of each size and type.
B. Lenses: 3 percent of quantity furnished, minimum of one of each size and type.
C. Ballasts: 3 percent of quantity furnished, minimum of one of each size and type.

1.06 WARRANTY

A. Ballasts: Provide manufacturer’s warranty for a period of not less than 5 years covering the full cost of a replacement ballast excluding labor.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Luminaires
   1. Requirements:
      a. Luminaire schedule catalog numbers are a reference to manufacturer design series and do not necessarily reflect the exact catalog number, size, voltage, wattage, type of lamp, ballast, finish trim, ceiling type, mounting hardware, ceiling trim or special requirements. Verify luminaire voltages with Contract Drawings.
      b. Provide luminaires, complete and ready for service. Provide Luminaires of the number, type, material, finish, electrical components, characteristics, and with the necessary hardware and auxiliary equipment, as indicated. List luminaires with provisions for raceways for this as being for this use. Comply also with applicable requirements and guidelines of the IES Lighting Handbook.
c. Mark luminaires clearly with manufacturer's name and catalog number, voltage, acceptable lamp type, maximum wattage, and label for intended use.

d. Verify luminaires are UL listed for the location and application intended.

e. Verify luminaires containing lamps which require protective shielding are provided with tempered glass lens.

f. Verify luminaires are free of light leaks and designed to provide required ventilation for electrical components. Verify luminaires control temperature of lamps such that lamps reach full light output under installed environmental conditions.

g. For adjustable luminaires, provide positive locking devices to fix aiming angle. Verify luminaires are capable of being relamped without affecting aiming angle.

h. Provide safety devices for removable luminaire elements (IE cones, reflectors, and lenses) to support removable elements when not in normal operating position. Provide safety devices that are detachable if necessary and do not interfere with luminaire performance, maintenance, or the seating of any luminaire element, and not be visible during normal operation.

2. Materials:

a. Supply products of thicknesses, gages, and tempers as indicated, and as recommended by the manufacturer for the specific finish, proper forming operations, and structural requirements.

b. For reflector material use prefinished, copper-free aluminum alloy, minimum thickness 0.032 inch, Architectural Type 1 with Class M1 anodic coating providing 83 percent reflectivity.

c. Verify the acrylic for lenses and diffusers is manufactured from virgin-acrylic extrusion or injection molding pellets.

d. Verify the polycarbonate for lenses is manufactured from high temperature resin designed for use with HID lamps.

e. Verify the glass for lenses is tempered borosilicate pressed or spun glass, minimum 0.13 inch thick.

f. Verify stainless steel is Type 304 conforming to ASTM A 167.

3. Finishes:

a. Provide luminaires completely factory-finished in colors to match the Resident Engineer's control samples and in accordance with the manufacturer's recommendations for the specific application.

b. Do not start finishing operations until fabrication and forming operations have been completed.

c. Finish ferrous mounting hardware and accessories to prevent corrosion and discoloration of adjacent materials. Where aluminum parts come
into contact with bronze or steel parts, apply a permanent finish to both surfaces to prevent corrosion.

d. Ensure Aluminum to be anodized is given a Class 1 anodic coating.

e. Anodize aluminum in accordance with procedures established by alloy manufacturer to achieve color within specified range.

f. Apply a clear organic protective coating to exposed aluminum surfaces that may experience prolonged contact with caustic material such as concrete or plaster.

g. Verify that the minimum cleaning of metal before painting is a five-stage phosphatizing system consisting of alkali cleaner, hot water rinse, zinc phosphatizing solution with toner, water rinse at room temperature, and chromic acid rinse for neutralizing.

h. Verify interior luminaires with surfaces not exceeding 150 degrees F are statically charged and painted two coats minimum of acrylic gloss enamel to a minimum total dry film thickness (DFT) of 2.5 mils.

i. Verify interior luminaires with surfaces exceeding a temperature of 150 degrees F, but not exceeding 300 degrees F, are statically charged and painted with silicone-alkyd enamel, two coats minimum to a total DFT of 2.5 mils.

j. For exterior or corrosive locations, finish luminaires and accessories with weather-resistant enamel using proper primers or bonderized epoxy over galvanized surfaces. Ensure the entire luminaire assembly is corrosion-resistant under the installed service conditions.

k. Provide luminaires specified to be painted with one coat of epoxy-polyamide at a minimum DFT of 2 mils and one coat of aliphatic urethane to a minimum DFT of 2 mils. Ensure interior reflective surfaces be painted as are interior luminaires.

l. For finish luminaires specified to be porcelain enameled, or painted luminaires with reflectors specified to be porcelain enameled, ensure they receive porcelain-enamel coating in accordance with the requirements of PEI-1001.

m. Finish reflective surfaces that are not specified to be specular to be gloss white, guaranteed nonyellowing, with a reflectance rating of not less than 88 percent.

n. Provide galvanized coating, where indicated, hot-dip galvanized according to ASTM A 123/A 123M. Where painting of the galvanized surface is indicated, pretreat the surface with a spray of zinc chromate-vinyl butyryl wash primer at least 0.05 mil thick; apply an 80 percent zinc dust, 20 percent zinc oxide, alkyd resin primer; and then apply a single-component, Type II, modified acrylic or polyurethane top coat.

B. Light Control Elements:

1. Reflector Cones:
a. Provide minimum 45-degree lamp and lamp image cut-off for vertically mounted lamps. Provide minimum 30-degree lamp and lamp image cut-off for horizontally-mounted lamps.

b. Do not use plastic materials for reflector cones, unless noted otherwise in the Luminaire Schedule.

c. Do not rivet or weld reflector cones to housing and ensure reflector cones are removable without tools. Ensure retention devices do not deform the cone. Install trim to be flush with finished ceiling without gaps or light leaks. Where the flange trim is separate from the cone, install with the same finish as the cone unless otherwise noted.

d. Ensure reflector cones are of uniform gage, not less than 0.032-inch, high purity aluminum alloy, free of spin marks or other defects.

e. Ensure reflectors have an Alzak or equal finish. Refer to luminaire schedule for cone color and specular or diffuse finish requirements. For luminaires using compact fluorescent lamps, provide additional finish equivalent to Color-Chek, which will eliminate iridescence.

2. Fresnel Lens and Door Assembly:

a. Use Lenses that have uniform brightness throughout the entire visible area at angles from 45 degrees to 90 degrees from vertical, without bright spots or striations.

b. Use Lenses that have opaque risers painted neutral gray unless otherwise specified in the luminaire schedule.

c. Finish regressed door with matte, baked enamel paint in color as selected by Resident Engineer.

C. Electrical Components:

1. Lampholders:

a. Provide lampholders and sockets in accordance with ANSI C78.380 and C81.62 and of the class and style recommended by the lamp manufacturer for the specific lamp required for each luminaire design and rated for 660 W, 600 V, or as indicated. Ensure lampholders hold lamps securely and withstand normal vibration and maintenance handling.

b. Fasten lampholders and sockets rigidly and securely to the mounting surface with the necessary provisions to be front removable without dismantling any part of the luminaire, and to prevent lampholder from turning.

c. Locate lampholders and sockets correctly in the luminaires to place each specified lamp in proper position with relation to the luminaire design and to ensure proper distribution of light. Clearly mark lampholders and sockets to indicate manufacturer, lamp type, voltage, and appropriate listings.

d. Provide incandescent and high intensity discharge lampholders of glazed porcelain body with nonferrous metal components of heavy duty design, vibration resistant.
1) Provide phenolic body, double contact, bayonet sockets rated 75 W, 125 V, for special compact fluorescent and low wattage incandescent lamps such as the 20 W T6-1/2.

2) Provide a high voltage mogul lampholder, 5 kV pulse rated, 1.5 kW, 600 V, for metal halide and high-pressure sodium lamps 250 W and up to and including 1 kW.

e. Provide fluorescent lampholders of white urea, spring loaded with silver-plated contacts of the pedestal or button type.

1) Supply rapid start lamps which use medium bipin spring-loaded lampholders of the tombstone or butt configuration.

2) Supply miniature fluorescent preheat and circline lamps which use special lampholders as recommended by the individual lamp manufacturer.

2. Ballasts:

a. Ensure ballasts are high efficiency, with high power factor (higher than 0.9) by the use of capacitor, with current crest factor of 1.6 or less and a minimum starting temperature of minus 20 degrees F. Ensure the ballast allow plus or minus 5 percent lamp watts variation for a plus or minus 10 percent input voltage variation.

b. Mount each ballast securely inside the luminaire to obtain the necessary heat dissipation. Ensure high intensity discharge ballasts comply with ANSI C82.4.

c. Installed pulse start metal halide lamps to be operated by a linear reactor type ballast with igniter or a constant wattage auto-transformer (CWA) type ballast to provide the required nominal 4kV (3kV to 5kV) pulse to start. Electronic ballasts are acceptable where the lamp/ballast combination has been approved by the lamp manufacturer.

d. Installed high intensity discharge luminaires to have a non-time delay automatically switched quartz standby light where indicated on the Contract Drawings. Ensure the quartz light turn on when power is restored and turn off when the HID lamp restrikes.

e. Installed high pressure sodium lamps, 250 W size and larger, to be operated by a constant wattage autotransformer (CWA) type ballast.

f. Ensure ballast for fluorescent lamps matches the characteristics of the lamps, and meets the following requirements:

1) Operate lamps at a frequency of 20 kHz or higher without visible flicker.

2) Be listed Class P for indoor or Type 1 outdoor applications.

3) Have total harmonic distortion of less than 10 percent at 277 V.

4) Have current crest factor of less than 1.5.

5) Have a power factor of 0.98 minimum.
6) Have an audible noise rating of Class A or better.
7) Contain no Polychlorinated Biphenyls (PCBs).
8) Comply with ANSI C62.41, Category A, for transient protection.
9) Have inherent thermal protection.
10) Provide constant light output with input voltage fluctuation of plus or minus 5 percent.
11) Provide instant-start for parallel wiring connection of lamps. Allow remaining lamps to maintain full output, in the event of lamp failure on multiple lamp luminaire.
12) Provide reliable lamp starting at 0 degrees F for luminaires located in unheated interior spaces and at 50 degrees F for luminaires located in heated interior spaces.

g. Ensure Ballasts for T5 fluorescent lamps be Programmed Start, electronic type suitable for high-output T5 fluorescent lamps.

h. Supply dimming ballasts, where required, of a type appropriate for the dimming controller and consistent with product listing. Ensure total harmonic distortion not exceed 20 percent at any point within the dimming range.

i. Electromagnetic Ballasts: Comply with ANSI C 82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
   1) Ballast Manufacturer Certification: Indicated by label.

j. Single Ballasts for Multiple Lighting Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

k. Ballasts for Low-Temperature Environments:
   1) Temperatures 0 Deg F and Higher: Electronic or electromagnetic type rated for 0 Deg F starting and operating temperature with indicated lamp types.

l. Ballasts for Compact Fluorescent Lamps: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated.
   1) Lamp end-of-life detection and shutdown circuit.
   2) Automatic lamp starting after lamp replacement
   3) Sound Rating: A.
   4) Total Harmonic Distortion Rating: Less than 20 percent.
   5) Transient Voltage Protection: IEEE C 62.41, Category A, or better.
6) Operating Frequency: 20 kHz, or higher.

7) Lamp Current Crest Factor: 1.7, or less.

8) BF: 0.95 or higher, unless otherwise indicated.

9) Power Factor: .098, or higher.

10) Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.

11) Ballast Case Temperature: 75 Deg C, maximum.

m. Ballasts for HID Lamps:

1) Electromagnetic Ballast for Pulse Start Metal-Halide Lamps: Comply with ANSI C 82.4 and UL 1029. Include the following features, unless otherwise indicated:
   a) Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
   b) Minimum Starting Temperature: Minus 22 Deg F for single-lamp ballasts.
   c) Normal Ambient Operating Temperature: 104 Deg F.
   d) Open-circuit operation that will not reduce average life.
   e) Low-Noise Ballasts: Manufacturers’ standard epoxy-encapsulated models designed to minimize audible fixture noise.

2) Electronic Ballast for Pulse Start Metal-Halide Lamps: Include the following features, unless otherwise indicated.
   a) Lamp end-of-life detection and shutdown circuit.
   b) Sound Rating: A.
   c) Total Harmonic Distortion Rating: Less than 15 percent.
   d) Transient Voltage Protection: IEEE C 62.41, Category A, or better.
   e) Lamp Current Crest Factor: 1.5, or less.
   f) Power Factor: .90, or higher.
   g) Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
   h) Protection: Class P thermal cutout.

3) High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter/starter shall have an average
life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 Deg C.

a) Minimum Starting Temperature: Minus 40 Deg F.

b) Open-circuit operation shall not reduce average lamp life.

3. Luminaire Wiring:

a. Provide luminaire wires of stranded tinned-copper construction, not smaller in wire size than 16 AWG. Provide insulation of silicone rubber type SF-2, 200 degrees C rated. Mark conductor size, temperature rating, voltage, and manufacturer clearly on the insulation of each conductor. Previously approved fixtures from the facility Lighting Fixtures list may deviate from these requirements.

b. Provide wires between lampholders and associated operating and starting equipment with the same ampacity rating as leads from the ballast. Provide wiring within the luminaries that complies with the National Electrical Code.

c. Tape wires at points of abrasion. Do not permit splices within luminaires other than as required to connect lampholders and ballast. Provide wireways and wiring channels with rounded edges or bushed holes wherever conductors pass through. Install insulated bushings at points of entrance and exit of wiring.

d. Ensure flexible cord wiring between luminaire components or to electrical receptacle but not in wireways has a minimum temperature rating of 105 degrees C.

e. Fit Cords with proper strain reliefs and watertight entries where used for damp or wet location luminaires.

f. Master/Slave luminaires: Supply ballasts in adjacent luminaires to operate one or more lamps in the adjacent luminaire where required by Contract Drawings. For single lamp luminaires, provide a two-lamp ballast for two adjacent luminaires. For three lamp luminaires, provide one two-lamp ballast for the outboard lamps and an additional two-lamp ballast for the center lamp in both luminaires.

g. Tandem-wired luminaires: For luminaires in continuous rows and where required by Contract Drawings, supply ballasts and wiring to control all top or inboard lamps together and control all bottom or outboard lamps together.

h. Dual-level switched luminaires: Provide multi-wire, flexible luminaire whips as required for luminaires designated as dual-level switched on the Contract Drawings.

4. Luminaire Grounding: Unless otherwise specified, provide the housing of each ballasted luminaire with a separate, factory-installed grounding device. Attach a separate grounding conductor to the grounding device on each luminaire housing.

D. Luminaire Hardware:
1. Ensure latch and release mechanism, hinges, pins, and other retaining parts of luminaires; screws, bolts, or other assembly and mounting parts are manufactured of Type 304 or Type 316 stainless steel. Provide springs of heavy duty stainless steel. Provide self-retaining type retaining hardware.

2. Ensure light transmitting panels are held in the frames in a neat, rattle-free manner that will provide proper tolerance for normal expansion and contraction.

3. Fabricate internal brackets from ASTM A 366/A 366M sheet steel, zinc-coated after fabrication, or finished extruded aluminum.

4. Verify that gaskets, sealants, and adhesives are formed from silicone rubber, or as indicated.

5. Provide bolts, nuts, washers, screws, nails, rivets, and other fastenings necessary for proper installation or assembly of work. Verify that items exposed to the atmosphere are made of 300 series stainless steel. Ensure fastenings within the housing are hot-dip galvanized steel and that nuts have captive externally-footed lockwashers.

6. Verify that junction boxes suitable for the intended location and wiring requirements are provided with four 3/4-inch threaded and plugged conduit entries.

E. Luminaire Mounting Hardware:

1. Provide luminaires with brackets, straps, canopies and stems, and miscellaneous hardware suitable for the mounting method specified. Ensure pendant mounted luminaires have seismic resistant swivel mountings.

2. When exposed to public view, fabricate and finish hardware in material matching the luminaire body.

3. Supply canopies, holders, and similar parts that are drawn or spun in one piece with a minimum 0.026-inch finished thickness.

4. Verify tubing used for stems is seamless drawn with a minimum of 1/16-inch wall thickness of size and length as indicated. Ensure stems are provided for pendant mounted luminaires of length as required for the specified mounting height with swivel hangers or ball aligners as required.

F. Lamps:

1. Requirements: Provide each luminaire with the number, type, and wattage of lamps required as indicated. Provide lamps used in the illumination system of standard manufacture, readily available, and of the highest efficiency and life consistent with other requirements of the illumination system. Ensure all lamps of each type are provided by a single manufacturer.

2. Compact Fluorescent Lamps: Configure as required by luminaire manufacturer. Ensure lamps have a rated minimum average life of 10,000 hours, minimum 82 Color Rendering Index (CRI) and minimum 2700 degrees Correlated Color Temperature (CCT).

3. Fluorescent Lamps:
a. Energy-efficient T8, rapid start fluorescent lamp rated 265 mA, wattage rating as indicated. Use lamps for T8 fluorescent lighting that have reduced mercury contents that meet U.S. Environmental Protection Agency (EPA) Toxic Characteristic Leaching Procedure (TCLP) test for nonhazardous fluorescent light waste pursuant to 22 CCR Section 66260.200 (e).

b. High-output T5, programmed start fluorescent lamp, wattage rating as indicated.

c. Ensure lamps have a rated minimum average life of 20,000 hours, minimum 78 Color Rendering Index (CRI), and minimum 3500 degrees K Correlated Color Temperature (CCT).

4. Metal Halide Lamps: Clear or coated as indicated, suitable for all operating positions. Ensure Photometric characteristics provide maximum luminous output while operating in the horizontal position with color temperature of 3700 degrees K and CRI of 70.

5. High Pressure Sodium Lamps: Clear or coated as indicated, suitable for all operating positions. Ensure Lamps have a rated minimum average life to 15,000 hours, minimum 60 Color Rendering Index (CRI) and minimum 2200 degrees K Correlated Color Temperature (CCT).


G. Steel Poles:

1. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; 1-piece construction up to 40 feet in height with access handhole in pole wall.
   a. Shape: Round tapered and square straight.

2. Steel Mast Arms: Single-arm and two-luminaire bracket type, continuously welded to pole attachment plate. Material and finish same as pole.

   a. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
   b. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
   c. Match pole materials and finish.

4. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

5. Steps: Fixed steel, with nonslip treads, positioned for 15-inch vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet above finished grade.
6. **Intermediate Handhole and Cable Support**: Weather-tight, 3-by-5-inch handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.

7. **Grounding and Bonding Lugs**: Welded 1/2-inch threaded lug, complying with requirements in Division 16, Section “Grounding and Bonding”, listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

8. **Cable Support Grip**: Wire mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

9. **Platform for Lamp and Ballast Servicing**: Factory-fabricated of steel with finish matching that of pole.

10. **Prime-Coat Finish**: Manufacturer’s standard prime coat finish ready for field painting.

11. **Galvanized Finish**: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.

12. **Factory-Painted Finish**: Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

   a. **Surface Preparation**: Clean surfaces to comply with SSPC-SP 1, “Solvent Cleaning”, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, “White Metal Blast Cleaning”, or SSPC-SP 8, “Pickling”.

   b. **Interior Surfaces of Pole**: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

   c. **Exterior Surfaces**: Manufacturer’s standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

      1) **Color**: As specified in the lighting schedule on plans.

H. **Pole Accessories**:

1. **Base Covers**: Manufacturers’ standard metal units, arranged to cover pole’s mounting bolts and nuts. Finish same as pole.

I. **Outdoor Photoelectric Switches**:

1. **Description**: Solid State, with dry contacts to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

   a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

   b. **Light-Level Monitoring Range**: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range, and a
directional lens in front of the photocell to prevent fixed light sources from causing turn-off.

c. Time Delay: Fifteen second minimum, to prevent false operation.

d. Surge Protection: Metal-oxide varistor.

e. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

J. Daylight-Harvesting Switching Controls

1. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, with separate power pack to detect changes in indoor lighting levels that are perceived by the eye.

2. Electrical Components, Devices, and Accessories:

   a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

   b. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).

   c. Sensor Output: Contacts rated to operate the associated power pack, complying with UL 773A. Sensor is powered by the power pack.

   d. Power Pack: Dry contacts rated for 20 -A ballast load at 120- and 277-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

   e. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lux), with an adjustment for turn-on and turn-off levels within that range.

   f. Skylight Sensors Light-Level Monitoring Range: 1000 to 10,000 fc (10 800 to 108 000 lux), with an adjustment for turn-on and turn-off levels within that range.

   g. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.

   h. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.

   i. Test Mode: User selectable, overriding programmed time delay to allow settings check.

   j. Control Load Status: User selectable to confirm that load wiring is correct.

   k. Indicator: Two digital displays to indicate the beginning of on-off cycles.

K. Indoor Occupancy Sensors:

1. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

b. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

c. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.

d. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

e. Mounting:
   1) Sensor: Suitable for mounting in any position on a standard outlet box.
   2) Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
   3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

f. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.

g. Bypass Switch: Override the "on" function in case of sensor failure.

h. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

2. PIR Type: Ceiling mounted; detect occupants in coverage area by their heat and movement.

a. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).

b. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

c. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

3. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.

a. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

b. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

d. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

e. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).

4. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

a. Sensitivity Adjustment: Separate for each sensing technology.

b. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.02 SOURCE QUALITY CONTROL

A. Test a typical representative unit of each luminaire that is clean, free from mechanical defects, equipped with the proper fittings, and with the lamp of the size and type in the position recommended for service operation.

B. Test UL-listed material, equipment, and components in accordance with UL standards. Test material, equipment, and components not covered by UL standards in accordance with nationally recognized standards. Provide material, equipment, and components bearing a label tag or certification of such inspection.

C. Perform and report tests for photometric performance in accordance with the approved methods outlined by the IES Lighting Handbook for photometric testing, and include data on candlepower, distribution, zonal lumens, maximum luminance values, and luminaire efficiency, including complete coefficients of utilization tables to indicate compliance with performance requirements.

2.03 RETROFIT KITS FOR FLUORESCENT LIGHTING FIXTURES

A. Comply with UL 1598 listing requirements.

1. Reflector Kit: UL 1598, Type I. Suitable for two- to four-lamp, surface-mounted or recessed lighting fixtures by improving reflectivity of fixture surfaces.

2. Ballast and Lamp Change Kit: UL 1598, Type II. Suitable for changing existing ballast, lamps, and sockets.
2.04 REQUIREMENTS FOR INDIVIDUAL LIGHTING FIXTURES

A. All interior luminaires individually are specified in the Lighting Schedule on plans.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Luminaires

1. Inspect surfaces and structures to, and on, which products will be installed before the work of this Section begins, and ensure that these surfaces are capable of supporting the products. Finish surfaces that will be concealed by products before products are installed.

2. Install luminaires as indicated, in accordance with the manufacturer's installation instructions and recommendations, and in accordance with NECA/IESNA 502, complete with lamps, hangers, brackets, poles, fittings, and accessories, ready for operation.

3. Install exposed parts of luminaires after construction, painting, and general cleanup in the area has been completed.

4. Align, mount, and level luminaires uniformly.

5. Avoid interference with, and provide clearance for, the equipment. Where the indicated locations for the luminaires conflict with the locations for other equipment, change the locations for the luminaires by the minimum distances necessary and as approved by the Resident Engineer.

6. For suspended luminaires, provide the indicated mounting height clearances between the bottoms of the luminaires and the finished floors.

7. Anchor luminaire supports to the structural slab or to structural members as indicated. Use supports to maintain the luminaire positions after cleaning and relamping. Provide supports for seismic loading in accordance with seismic requirements in Section 26 05 00 Common Work Results for Electrical.

8. Bracket surface-mounted luminaires rigidly from the mounting surfaces. Provide 1/4-inch clearance between surfaces when the luminaire is flat-mounted against concrete surfaces. Install luminaires with a noncumulative dimensional alignment tolerance of 1/16 inch when mounted in continuous runs with 1-inch spacing between individual luminaires. Ensure nipples carrying wires between luminaires are watertight.

9. Where aluminum is placed in contact with dissimilar materials, except galvanized steel, zinc, or stainless steel, treat contact surfaces as follows:

a. When in contact with dissimilar metals, apply a prime coat of zinc chromate primer followed by two coats of aluminum and masonry paint.

b. When in contact with concrete, masonry, and plaster, apply to aluminum contact surfaces zinc chromate primer, bituminous paint, aluminum and masonry paint, or pressure-sensitive tape.
c. When in contact with wood or other absorptive materials, apply two coats of aluminum house paint to such materials, and protect aluminum contact surfaces with bitumastic paint.

10. Provide pendant luminaires with stem swivel hangers to ensure a plumb installation with a minimum 45-degree swing from horizontal in all directions. Where 45-degree movement of luminaire is not possible due to field conditions, provide, in addition to above, cross bracing of aircraft cable to restrict movement in direction of potential contact. Use tubing that is not less than 3/16-inch diameter. Ensure that motion of swivels or hinged joints does not cause sharp bends in conductors or damage to insulation. For heavy pendant-mounted luminaires, where support is to be independent of the outlet box, provide stem swivel hangers with luminaire studs.

11. Install pole-mounted luminaires in accordance with manufacturer's installation instructions.

12. Provide required lamps in each luminaire as soon as luminaires are properly installed.

13. Refer to architectural reflected ceiling drawings to coordinate luminaire locations with mechanical and fire protection equipment. Notify Resident Engineer of all conflicts.


15. Enclose luminaires located in recessed ceilings with a fire-resistive rating of one-hour or more in an approved fire-resistive rated box equal to that of the ceiling.

16. Ensure fluorescent lamps operating with dimming ballasts are operated at full light output for 100 hours prior to dimming.

17. Adjust variable-position lampholders to proper lamp position prior to luminaire installation.

18. For pendant-mounted luminaires, mounting height is from finished ceiling to top of luminaire.

19. Provide 72-inch flexible conduit whip for recessed luminaires located in suspended ceilings.

B. Ballasts:

1. Install ballasts, other than those mounted integrally within luminaires, in such a manner that the ballast is protected from weather, moisture, and other atmospheric conditions, and in ambient temperatures that will not cause the temperature of the ballast housing hot-spot to exceed manufacturer's requirements.

2. Ensure voltage drop to lamp, due to remote ballast mounting, does not exceed 1 percent of the nominal lamp voltage. Provide secondary ballast conductors with 1 kV insulation. When more than one ballast is mounted at one location, install with the minimum spacing between ballasts being 6 inches in a horizontal direction and 12 inches in a vertical direction. Mount ballast components securely inside the luminaire in such a manner as to obtain the necessary heat dissipation.
C. Poles:

1. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

2. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings.
   a. Fire Hydrants and Storm Drainage Piping: 60 inches.
   c. Trees: 15 feet.

3. Concrete Pole Foundations: Set anchor bolts according to anchor bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 3, Section “Cast-in-Place Concrete”.

4. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
   a. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   b. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
   c. Install base covers, unless otherwise indicated.
   d. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

5. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring to a level 1-inch below top of concrete slab.

6. Raise and set poles using web fabric slings (not chain or cable).

3.02 FIELD QUALITY CONTROL

A. Deliver luminaires and lighting equipment to the Project site complete with related items, completely wired and assembled.

B. Inspect luminaires, lamps, and associated hardware before and after installation to ensure that they are of the quality and type specified and indicated, and are free of defects and damage.

C. Whenever practicable, test lighting systems at the same time that the distribution panelboard or switchboard is tested.

D. Adjust aperture rings on recessed luminaires to be flush with the finished ceiling.

E. Replace luminaires and components with damaged finishes or repair them to the satisfaction of the Resident Engineer prior to project closeout.

F. Install new lamps in luminaires with failed lamps not earlier than 48 hours before the date of final inspection.
G. Replace lamps that fail within 90 days after final acceptance without additional cost to Sound Transit.

H. Comply with all commissioning and testing requirements outlined in Section 25 08 00, Commissioning of Integrated Automation.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK
   A. Section includes requirements for design, procurement, installation, termination, testing, labeling, and documentation of fiber optic cables and ancillary

1.02 RELATED SECTIONS
   A. Section 01 12 16, Work Sequence
   B. Section 01 33 00, Submittal Procedures
   C. Section 01 45 00, Quality Assurance / Quality Control
   D. Section 01 78 39, Project Record Documents
   E. Section 01 95 00, System Testing and Integration
   F. Section 25 60 00, Building Management System (BMS)

1.03 REFERENCES
   A. Abbreviations and Acronyms
      1. dB  decibels
      2. BER  bit error rate
      3. BMS  building management system
      4. CMT  cable management tray
      5. EFN  Emergency Fan Network
      6. EMD  equilibrium modal distribution
      7. FDP  fiber distribution panel
      8. m  micron
      9. mW  milliwatts
     10. NA  numerical aperture
     11. nm  nanometer
     12. nW  nanowatts
     13. OLTS  optical loss test set
     14. OTDR  optical time domain reflectometer
15. POF plastic optical fiber
16. PCS plastic clad silica
17. WDM wave division multiplexing
18. SMF single mode fiber
19. TCN Train Control Network

B. Definitions

1. Analog: Signals that are continually changing, as opposed to being digitally encoded.
2. Attenuation: The reduction in optical power as it passes along a fiber, usually expressed in decibels (dB). See Loss, optical.
3. Attenuator: A device that reduces signal power in a fiber optic link by inducing loss.
4. Average power: The average over time of a modulated signal.
5. Backscattering: The scattering of light in a fiber back toward the source, used to make OTDR measurements.
6. Bandwidth: The range of signal frequencies or bit rate within which a fiber optic component, link or network will operate.
8. Bit: An electrical or optical pulse that carries information.
9. Bit-error rate (BER): The fraction of data bits transmitted that are received in error.
11. Cable Plant, Fiber Optic: The combination of fiber optic cable sections, connectors and splices forming the optical path between two terminal devices.
12. Cable: One or more fibers enclosed in protective coverings and in some cable constructions, strength members, stiffeners, water blocking compounds or other components.
14. Cladding: The lower refractive index optical coating over the core of the fiber that “traps” light into the core. Connector: A device that provides for a demountable connection between two fibers or a fiber and an active device and provides protection for the fiber.
15. Connector: A device which terminates an optical fiber and allows temporary joining of fibers with like terminations.
16. Core: The center of the optical fiber through which light is transmitted.
17. **Coupler:** An optical device that splits or combines light from more than one fiber.

18. **Cutoff wavelength:** The wavelength beyond which singlemode fiber only supports one mode of propagation.

19. **dBm:** Optical power referenced to 1 milliwatt.

20. **Decibel (dB):** A unit of measurement of optical power which indicates relative power on a logarithmic scale, sometimes called dBr. dB=10 log (power ratio)

21. **Detector:** A photodiode that converts optical signals to electrical signals.

22. **Digital:** Signals encoded into discrete bits.

23. **Dispersion:** The temporal spreading of a pulse in an optical waveguide. May be caused by modal or chromatic effects.

24. **Excess loss:** The amount of light lost in a coupler, beyond that inherent in the splitting to multiple output fibers.

25. **Ferrule:** A precision tube which holds a fiber for alignment for interconnection or termination. A ferrule may be part of a connector or mechanical splice.

26. **Fiber Amplifier:** An all optical amplifier using erbium or other doped fibers and pump lasers to increase signal output power without electronic conversion.

27. **Fiber identifier:** A device that clamps onto a fiber and couples light from the fiber by bending, to identify the fiber and detect high speed traffic of an operating link or a 2 kHz tone injected by a test source.

28. **Fiber optics:** Light transmission through flexible transmissive fibers for communications or lighting.

29. **Fiber tracer:** An instrument that couples visible light into the fiber to allow visual checking of continuity and tracing for correct connections.

30. **FO:** Common abbreviation for "fiber optic."

31. **Fresnel reflection, reflection, back reflection, optical return loss:** Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass. Typically 4% of the incident light.

32. **Fusion splicer:** An instrument that splices fibers by fusing or welding them, typically by electrical arc.

33. **Index matching fluid:** A liquid used of refractive index similar to glass used to match the materials at the ends of two fibers to reduce loss and back reflection.

34. **Index of refraction:** A measure of the speed of light in a material.

35. **Index profile:** The refractive index of a fiber as a function of cross section.

36. **Insertion loss:** The loss caused by the insertion of a component such as a splice or connector in an optical fiber.

37. **Jacket:** The protective outer coating of the cable.

38. **Jumper cable:** A short single fiber cable with connectors on both ends used for interconnecting other cables or testing.
39. Laser diode, ILD: A semiconductor device that emits high powered, coherent light when stimulated by an electrical current. Used in transmitters for singlemode fiber links.

40. Launch cable: A known good fiber optic jumper cable attached to a source and calibrated for output power used as a reference cable for loss testing. This cable must be made of fiber and connectors of a matching type to the cables to be tested.

41. Light-emitting diode, LED: A semiconductor device that emits light when stimulated by an electrical current. Used in transmitters for multimode fiber links.

42. Link, fiber optic: A combination of transmitter, receiver and fiber optic cable connecting them capable of transmitting data. May be analog or digital.

43. Long wavelength: A commonly used term for light in the 1300 and 1550 nm ranges.

44. Loss budget: The amount of power lost in the link. Often used in terms of the maximum amount of loss that can be tolerated by a given link.

45. Loss, optical: The amount of optical power lost as light is transmitted through fiber, splices, couplers, etc.

46. Margin: The additional amount of loss that can be tolerated in a link.

47. Max: Maximum

48. Mechanical splice: A semi-permanent connection between two fibers made with an alignment device and index matching fluid or adhesive.

49. Micron (*m): A unit of measure, 10-6 m, used to measure wavelength of light.

50. Microscope, fiber optic inspection: A microscope used to inspect the end surface of a connector for flaws or contamination or a fiber for cleave quality.

51. Modal dispersion: The temporal spreading of a pulse in an optical waveguide caused by modal effects.

52. Mode field diameter: A measure of the core size in singlemode fiber.

53. Mode filter: A device that removes optical power in higher order modes in fiber.

54. Mode scrambler: A device that mixes optical power in fiber to achieve equal power distribution in all modes. Mode stripper: A device that removes light in the cladding of an optical fiber.

55. Mode: A single electromagnetic field pattern that travels in fiber.

56. Multimode fiber: A fiber with core diameter much larger than the wavelength of light transmitted that allows many modes of light to propagate. Commonly used with LED sources for lower speed, short distance links.

57. Nanometer (nm): A unit of measure, 10-9 m, used to measure the wavelength of light.

58. Network: A system of cables, hardware and equipment used for communications.
60. Optical amplifier: A device that amplifies light without converting it to an electrical signal.
61. Optical fiber: An optical waveguide, comprised of a light carrying core and cladding which traps light in the core.
62. Optical loss test set (OLTS): An measurement instrument for optical loss that includes both a meter and source.
63. Optical power: The amount of radiant energy per unit time, expressed in linear units of Watts or on a logarithmic scale, in dBm (where 0 dB = 1 mW) or dB* (where 0 dB* = 1 microWatt).
64. Optical return loss, back reflection: Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass. Typically 4% of the incident light. Expressed in dB relative to incident power.
65. Optical switch: A device that routes an optical signal from one or more input ports to one or more output ports.
66. Optical time domain reflectometer (OTDR): An instruments that used backscattered light to find faults in optical fiber and infer loss.
67. Overfilled launch: A condition for launching light into the fiber where the incoming light has a spot size and NA larger than accepted by the fiber, filling all modes in the fiber.
68. Photodiode: A semiconductor that converts light to an electrical signal, used in fiber optic receivers.
69. Pigtail: A short length of fiber attached to a fiber optic component such as a laser or coupler.
70. Plastic optical fiber (POF): An optical fiber made of plastic.
71. Plastic-clad silica (PCS) fiber: A fiber made with a glass core and plastic cladding.
72. POF: plastic optical fiber, optical fiber made from polymer materials.
73. Power budget: The difference (in dB) between the transmitted optical power (in dBm) and the receiver sensitivity (in dBm).
74. Power meter, fiber optic: An instrument that measures optical power emanating from the end of a fiber.
75. Preform: The large diameter glass rod from which fiber is drawn.
76. Receive cable: A known good fiber optic jumper cable attached to a power meter used as a reference cable for loss testing. This cable must be made of fiber and connectors of a matching type to the cables to be tested.
77. Receiver: A device containing a photodiode and signal conditioning circuitry that converts light to an electrical signal in fiber optic links.
78. Reference cable: A known good fiber optic jumper cable attached to a light source or power meter used as a reference cable for loss testing.

79. Reflectance: Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass.

80. Refractive index: A property of optical materials that relates to the velocity of light in the material.

81. Repeater, regenerator: A device that receives a fiber optic signal and regenerates it for retransmission, used in very long fiber optic links.

82. Scattering: The change of direction of light after striking small particles that causes loss in optical fibers.

83. Short wavelength: A commonly used term for light in the 665, 790, and 850 nm ranges.

84. Singlemode fiber: A fiber with a small core, only a few times the wavelength of light transmitted, that only allows one mode of light to propagate. Commonly used with laser sources for high speed, long distance links.

85. Source: A laser diode or LED used to inject an optical signal into fiber.

86. Splice (fusion or mechanical): A device that provides for a connection between two fibers, typically intended to be permanent.

87. Splitting ratio: The distribution of power among the output fibers of a coupler.

88. Steady state modal distribution: Equilibrium modal distribution (EMD) in multimode fiber, achieved some distance from the source, where the relative power in the modes becomes stable with increasing distance.

89. Step index fiber: A multimode fiber where the core is all the same index of refraction.

90. Surface emitter LED: A LED that emits light perpendicular to the semiconductor chip. Most LEDs used in data communications are surface emitters.

91. Talkset, fiber optic: A communication device that allows conversation over unused fibers.

92. Termination: Preparation of the end of a fiber to allow connection to another fiber or an active device, sometimes also called "connectorization".

93. Test cable: A short single fiber jumper cable with connectors on both ends used for testing. This cable must be made of fiber and connectors of a matching type to the cables to be tested.

94. Test kit: A kit of fiber optic instruments, typically including a power meter, source and test accessories used for measuring loss and power.

95. Test source: A laser diode or LED used to inject an optical signal into fiber for testing loss of the fiber or other components.

96. Total internal reflection: Confinement of light into the core of a fiber by the reflection off the core-cladding boundary.
97. **Transmitter**: A device which includes a LED or laser source and signal conditioning electronics that is used to inject a signal into fiber.

98. **Visual fault locator**: A device that couples visible light into the fiber to allow visual tracing and testing of continuity. Some are bright enough to allow finding breaks in fiber through the cable jacket.

99. **Watts**: A linear measure of optical power, usually expressed in milliwatts (mW), microwatts ("W) or nanowatts (nW).

100. **Wavelength division multiplexing (WDM)**: A technique of sending signals of several different wavelengths of light into the fiber simultaneously.

101. **Wavelength**: A measure of the color of light, usually expressed in nanometers (nm) or microns ("m).

102. **Working margin**: The difference (in dB) between the power budget and the loss budget (i.e. the excess power margin).

C. **Reference Standards**

1. **ASTM International (ASTM)**

2. **Institute of Electrical and Electronic Engineers (IEEE)**
   - IEEE 383: Vertical Flame Test, Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations

3. **International Organization of Standardization (ISO)**
   - ISO 9001: Standard Quality Management Systems

4. **National Fire Protection Association (NFPA)**
   - NFPA 70: National Electrical Code
   - NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems
   - NFPA 262: Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

5. **Naval Engineering Standard (NES)**
   - NES 711: Smoke
   - NES 713: Toxicity

6. **Telecommunication Industry Association/Electronic Industries Alliance (TIA/EIA)**
   - TIA/EIA 455-B: Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
c. TIA/EIA 455-124: Polarization-Mode Dispersion Measurement for Single-Mode Optical Fibers by Interferometry

d. TIA/EIA 455-175B: Measurement Methods and Test Procedures - Chromatic Dispersion


f. TIA/EIA 598: Fiber Optic Color Code

g. TIA/EIA 568-B.1-2: Commercial Building Cabling for Telecommunications Products and Services


i. TIA/EIA-569A: Commercial Building Standard for Telecommunications Pathways and Spaces

7. Telcordia

a. GR-449-CORE: Generic Requirements and Design Considerations for Fiber Distributing Frames

b. GR-20-CORE: Generic Requirements for Optical Fiber and Optical Cable Specifications

8. Underwriters Laboratories (UL)

a. UL 224: Extruded Insulating Tubing

b. UL 910: Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air

c. UL 1666: Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.04 SUBMITTALS

A. Refer to Section 01 33 00 [SH15][MK16], Submittal Procedures, for submittal requirements and procedures.


1. Submit complete manufacture technical data sheets for the fiber cable and fiber termination equipment proposed to furnish. Demonstrate compliance with mechanical and optical properties specified herein.

2. Submit information for each proposed manufacturer describing his experience in manufacturing fiber optical cable, splice equipment, and termination equipment for rapid transit and railroad applications and quality assurance program and warranty.

3. Submit information for each proposed fiber contractor describing his experience in installation and testing of fiber optical cable, splice equipment, and termination...
equipment for rapid transit and railroad applications and quality assurance program and warranty.

4. Submit fiber cable system schematic, plan, and detail drawings, indicating complete fiber cable system, cable lengths, innerduct quantity, equipment placement within station and cross-passages. Include profiles showing location of cabinets/racks, rack elevation drawings, including all fiber termination details. Specify cable fiber cable labeling in accordance with Sound Transit existing standards.

5. Submit calculations for each fiber optic cable span and fiber link budget calculations.

6. Submittal shall include materials, equipment, assembly and installation required to carry out functions and purposes indicated in these Specifications, and to make the system suitable for the purpose for which it is intended, whether or not such materials, equipment, assembly and installation are specially indicated in the requirements of these Specifications.

7. Submit approved step by step termination, connector, and pigtail splicing instruction in accordance with manufacture supplied documentation for fiber optic equipment to be utilized as part of the fiber cable system.

C. Fiber Cable Installation/Pull Plan.

1. Submit Installation plan as outlined herein.

D. Fiber Test Equipment.

1. Submit Manufacture cut sheets and user documentation for Fiber Optic test equipment and test viewing software to be utilized as part Fiber optic installation and testing.

E. Testing Documents.

1. General: Submit documents in accordance with Section 01 95 00[SH17][MK18], System Testing and Integration.

2. Submit Test Program Plan, Test Procedures, and Test Results for each Test.

3. Submit Test Procedures for each test a minimum of 60 Days prior to date test is to be performed.

4. Factory Production Test:

   a. Submit Certified Test Report prior to shipment, in accordance with Section 01 45 00[SH19][MK20], Quality Assurance / Quality Control.

5. Pre-Installation Reel Test: Submit Fiber Cable Reel Test Report after shipment, but prior to Installation.

6. Fiber Cable Termination/Splicing Testing: Submit test results for individual pigtail splices in accordance with approved procedure.

7. Fiber Cable Field Tests: Submit end to end test results of OTDR[SH21][MK22] and Power Meter tests in accordance with approved procedures.
1.05 QUALITY ASSURANCE/QUALITY CONTROL (CABLE MANUFACTURER)

A. Wire and cable manufacturers, quoted products and installation vendors shall be approved by Resident Engineer. Provide qualification data and make arrangements for required demonstrations and tests.

B. Qualifications.

1. Past Performance and Experience: Cable manufacturers shall demonstrate previous successful experience in supplying wire and cable specified herein. Provide a list of three such installations of similar size and scope for each cable manufacturer to be considered.

2. Quality Assurance Program: Cable manufacturers, in accordance with requirements of these Specifications, are required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. Resident Engineer reserves the right to audit the manufacturer's facilities for conformance to the Contract including, but not limited to first article inspections, source inspections and on-site surveys. Prime concern shall be focused on formal assurance requirements to ensure manufacturer cannot attribute cable failure to actions or lack of actions.

3. Technical Data: Provide technical data that demonstrates compliance with the requirements of these Specifications for each cable type Contractor plans to supply (i.e. White Papers, Certifications).

4. Factory Design Tests: Make arrangements with prospective cable manufacturers to perform factory design tests as required by Resident Engineer.

5. Sample Specimens: If requested, furnish Resident Engineer sample specimens in 4 foot lengths identical to proposed cable including connectors and peripherals. Sample specimens shall remain property of Sound Transit.

6. Manufacturers shall certify compliance with the following warranty prior to selection:

   a. Manufacturers warrant that design, material, and workmanship incorporated in each item of cable is of the highest grade and consistent with established, and generally accepted, standards for aerial and underground cable for transit applications; and that each such item and every part and component thereof shall comply with these Specifications.

   b. Manufacturers agree this warranty shall commence with acceptance of each item of cable, whether defect is patent or latent, and shall continue for a period of 8 years after initial satisfactory operation of the item or 10 years after acceptance of item, whichever is shorter.

C. After Manufacture Selection.

1. Monitor manufacturers of cable to assure that approved Quality Assurance Program is being closely adhered to and that wire and cable are being manufactured in accordance with these Specifications and approved submittals.

2. Each finished cable must be traceable to test date on file for each step in its manufacturing process.
D. Inspection.

1. Resident Engineer shall have the right to make such inspection and tests as necessary to determine if the cable meets requirements of these Specifications.

2. Resident Engineer shall have the right to reject cable that is defective in any respect.

3. Provide Resident Engineer 15 Days advance notice of date cable will be ready for final testing so that Sound Transit may witness the tests, if it so elects.

4. Physical Tests: Perform physical random tests on samples selected at the place of production. Take each test sample from accessible end of different reels. Identify each reel selected with corresponding sample. Specify number and length of samples under individual tests. Perform tests for cable materials and cable construction specified.

5. Resident Engineer reserves the right to conduct any test to provide further satisfaction that cable is manufactured in accordance with requirements of these Specifications.

1.06 QUALITY ASSURANCE (QUALIFIED FIBER INSTALLATION AND TEST PERSONNEL)

A. Fiber optic work required to be performed requires a contractor with specialized knowledge and training. Contractor shall be certified by an accredited training organization, and have been and approved contractor by the following Telco or fiber cable Providers:

1. BICSI (Building Industry Consulting Services Intl), FOA (Fiber Optic Association).

2. AT&T, Verizon, or Sprint Approved Contractor with Tier 2 Certification.

3. Corning Cable Systems Trained.

B. Fiber optic cable contractors shall be well trained, experienced and qualified to perform fiber optic cable splicing. To be considered for approval for fiber optic work, the installer/splicer must be recommended by the fiber cable manufacturers, have had recent satisfactory experience in performing all aspects of fiber optic work, with a minimum of 15 years field experience.

C. Fiber Contractor must have verifiable experience in the following aspects of Fiber optic work:

1. Complete fiber optic splicing (fusion and/or mechanical).

2. Complete testing services, such as end to end, reel testing, and splice loss testing, ORL, power meter/laser source testing and fiber characterization testing (10GigE certification).


4. Emergency restoration and in-service "hot cuts", Balloon-lateral splices.

5. Rodding & Duct proofing, innerduct installation.

6. Installation within underground ducts/manhole environments, Certified in Confined Space Entry.
7. Place fiber cable -- all sizes.


9. Experience working within active Transportation Right of ways-including constrained working hours.


D. If during any process involving fiber optic cable work the Resident Engineer determines the fiber installation/splice personnel are found to exceed the listed reasonable average time periods of work performance for a given task for no cause, and installation schedules are being affected, the Contractor shall be required to replace installer/splice personnel with more capable personnel that shall complete the installation and splicing work in the prescribed time period at no additional expense to Sound Transit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing.

1. Ship cable on non-returnable wooden reels.

2. Drum Diameter: Minimum 20 times the diameter of cable.

3. Reels: Substantial enough to withstand reasonable handling, designed with inner end of accessible but protected from injury.

4. Cable Ends: Sealed to prevent entrance of moisture and securely fastened to prevent ends from becoming loose during transit.

B. Marking.

1. Mark each reel on outside flange with the following information:
   a. Manufacturer's name.
   b. Contract name and number.
   c. Cable identification number.
   d. Cable length.
   e. Date of manufacture.

C. Delivery.

1. Inspect cables at time of delivery at construction site to assure no damage was done during shipping.

2. Inspect every reel for physical damage.

3. Submit to Resident Engineer cable reel inspection report.

4. Replace damaged or rejected cable promptly at no cost to Sound Transit.

D. Storage.

1. Store cables on solid surfaces designed to support cable reels which drain adequately and do not allow accumulation of liquids, oils, or chemicals.
2. Align and protect cable reels so as not to allow reel flanges to damage other reels.

3. Provide adequate aisles and barricades to allow accessibility and to prevent construction equipment from damaging cable reels.

4. Reseal cable ends promptly when a length is cut from reel.

E. Handling.

1. Handle cable reels using a sling and spreader attached to a shaft through the reel hubs, or by cradling both flanges between lift truck forks.

2. Do not lift reels by top reel flange or drop from any height.

3. Ensure lift truck forks do not touch cable surfaces on reel.

4. Roll reels in the direction opposite the cable wind on reel.

5. Do not lay reels flat.

PART 2 - PRODUCTS

2.01 FIBER OPTIC CABLE

A. The installation environment will include existing Link communications system facilities, underground and tunnel duct-banks, embedded and surface conduit, communications manholes and handholds, cross-passages, and station systems equipment rooms.

B. General

1. Fibers shall be usable and meet required specifications.

2. The life expectancy of the cable shall be 25 years for service in a railroad and transit environment.

3. The cable shall be designed for installation in underground conduit, wet or dry environments, including alternating wet and dry conditions.

4. Fillers: Solid polyethylene, or similar material, rods of same diameter as buffer tubes.

5. Identification:
   a. Cable Print: White, indented into outer jacket.
   b. Apply cable print to outer jacket with the following information:
   c. Cable Manufacturer.
   d. Number of Fibers.
   e. Fiber Type, Single Mode Fiber (SMF).
   f. Halogen Free, Low Smoke.
   g. Date Coded Month Year (MMYY).
   h. Sequential Marking (a mark every foot or meter).
C. Application Descriptions.
1. BMS I/O network fiber - 12 strand single mode inter-station outside plant fiber cable to be utilized for direct data connections between field equipment. Manufacture Draka DLSZHC Heavy Duty Duct Cable, or approved equal.

D. Construction Characteristics.

<table>
<thead>
<tr>
<th>Cable Property</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Tension Installation</td>
<td>1000lbs</td>
</tr>
<tr>
<td></td>
<td>Operating: 200lbs</td>
</tr>
<tr>
<td>Bend Radius Installation</td>
<td>11.4 in.</td>
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<tr>
<td></td>
<td>Operating: 5.7 in.</td>
</tr>
<tr>
<td>Cable O.D. (Max)</td>
<td>0.541 in.</td>
</tr>
<tr>
<td>Cable Weight (max)</td>
<td>141lbs/1000ft</td>
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<tr>
<td>Buffer Tube Configuration</td>
<td>Loose tube</td>
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<tr>
<td></td>
<td>6 fiber strands per tube</td>
</tr>
<tr>
<td>Rating</td>
<td>OFN-LS</td>
</tr>
<tr>
<td>Buffer Tube</td>
<td>polymeric insulation, moisture-resistant, water blocking, fillers, where required shall be dialectic material.</td>
</tr>
<tr>
<td>Central Strength Member</td>
<td>dielectric material (epoxy/fiberglass rod)</td>
</tr>
<tr>
<td>Dry Block Tape</td>
<td>swellable tape wrapped around the cable core to prevent water penetration</td>
</tr>
<tr>
<td>Strength Member</td>
<td>aramid yarn (both Inner-Outer layers).</td>
</tr>
<tr>
<td>Jacket type</td>
<td>thermoplastic LSZH polyolefin</td>
</tr>
</tbody>
</table>

E. Optical Characteristics.

<table>
<thead>
<tr>
<th>Property</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating</td>
<td>acrylate for mechanical protection.</td>
</tr>
<tr>
<td>Strand Color</td>
<td>Per TIA/EIA-598</td>
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<tr>
<td>Fiber strand Core Diameter</td>
<td>8.2 to 8.8 Microns</td>
</tr>
<tr>
<td>Fiber strand Diameter</td>
<td>125 Microns</td>
</tr>
<tr>
<td>Fiber Type</td>
<td>Step index</td>
</tr>
<tr>
<td>Attenuation</td>
<td>0.35 dB/km at 1310 nm 0.25 dB/km at 1550 and 1625 nm.</td>
</tr>
</tbody>
</table>

2.02 FIBER SPLICE CASE

A. Provide splice cases suitable for: underground manhole cable vaults, outside plant, uncontrolled environments or at building entry point when space permits. Splice cases shall be placed at locations as shown on Contract Drawings.

B. Manufacturer: Provide by company Preformed Line Products, 3M, Corning, or approved equal [SH23],[MK24]
C. Uncontrolled Environment: Location in which temperature and humidity are not artificially regulated, where relative humidity can exceed 50 percent, or where liquid may come into contact with the fiber cable core.

D. Construction: Cylindrical design having two points of entry (one in each end of the cylinder) for at least four cables in each point. Splice cases shall be re-enterable and re-sealable to support fiber cable repair and or expansion.

E. Entry Points: Flexible compression type fitting having a single compression gasket between two type 304 stainless steel plates.

F. Environmental Requirements: Withstand submersion up to a depth of 10 feet for a period of 10 Days without leaking, withstand three repeat blows of 9000N without failure or leakage via submersion test.

G. Material: Corrosion resistant material equal to or superior in corrosion resistance to type 304 stainless.

H. Fill: Dry-type encapsulates to allow future re-entry and prevent water incursion, no gel type.

I. Size: Provide up to 288 single-fiber splices. Provide storage room for unspliced express fiber buffer tubes pass through. Support Ring Cut, loop-through splicing.

J. Hardware: Splice case internal configuration to support: in-line, butt, or branch splicing methods. Internal components to include: splice cassette carrier, splice holder cassette, splice blocks, coil support assemblies, mounting brackets, and all required associated accessories.

K. Supply splice case mounting hardware such that case may be secured to installation location and that cables have sufficient strain relief to prevent damage under frequent movement and harsh conditions.

2.03 FIBER DISTRIBUTION PANEL - RACK MOUNT

A. Utilize Fiber Distribution Panel (FDP) for termination, storage and distribution of the fiber optic cable system, and provide a convenient point for splicing outside plant fiber optic cables to pigtails. FDPs shall be a complete system of components by a single manufacture.

B. FDP shall comply with Telcordia GR-449-CORE.

1. Provide Cable Management Tray (CMT) series Termination/Storage/Splice panels by ADC or approved equal.

C. Provide FDPs capable of terminating 12, 24, 36, 48, or 144 fibers strands, as shown on Contract Drawings. Final FDP port quantities in accordance with final design of fiber cable termination requirements.

D. Size: Chassis (width: 17.4 inch) x (depth: 12.0 inch) x (height: min. 1.75 inch, max. per FDP port quantities). Housing shall be rack mountable per EIA-310, in either 19 inch or 23 inch wide rack rail spacing.

E. Furnished fully loaded FDP complete with Subscriber Connector bulkheads with Ultra Polish Connector pigtails pre-connectorized to 900µm jacket, color coded per TIA/EIA-598, heat shrink fusion splice trays, a splice drawer, cable rubber clamps, and FDP front cover.
F. FDP shall incorporate labeling provisions that correspond to each fiber port location. Labeling shall be viewable from front of FDP.

G. All connectors and accessory items to be compatible with new and existing optical fiber transmission equipment.

H. Outside plant cables shall be routed to the fiber panels and secured to the outside of the chassis, FDP shall provide for tie point for securing fiber cable central member.

I. Route each optical fiber into the chassis and splice tray for splicing into a pigtail assembly.

J. Sharp edges in areas where fiber may be damaged in/out of FDP is prohibited. Cable entrances shall have grommet and cable clamp strain relief.

K. Completed splices shall be mounted in splice trays for protection. Splice trays shall be capable of securely holding up to 24 individual fusion splices.

L. Splice trays, pigtails and optical fiber buffer tubes shall be stored at the bottom of the FDP in extendable splice draws. The FDP shall be furnished with Cable Management Trays (CMT) where fiber bulkhead plates are mounted, trays shall be swing out design for access to front and rear of fiber bulkhead terminals.

M. Each CMT shall store at least 8-10 meters of fiber optic pigtails, patch cords or a combination thereof.

N. Bend radii inside the CMT shall be greater than 2 inches.

O. The FDP must protect the fiber throughout the panel.

P. Provide protective dust caps for all fiber ports.

Q. Accessibility for Fiber Splice Trays, Cable Management Tray, and Fiber Ports shall be from the front. Rear panel shall be removable.

2.04 FIBER DISTRIBUTION PANEL (FDP)-WALL MOUNT

A. Provide Two Door wall mount chassis fiber cable termination/splice box.

1. Provide model FL1000 Series by ADC or approved equal.

B. Terminations: Provide fully loaded 48 terminations with 8 required bulkhead plates, 6 ports per plate.

C. Bulkhead Plates: 6 Ports with SC bulkhead adaptors and 6 SM SC/UPC 900µm color coded per TIA/EIA-598-connectors/pigtails.

D. FDP shall incorporate labeling provisions that correspond to each fiber port location. Labeling shall be viewable from front of FDP.

E. Provide required splice trays for complete installation of 48 terminations.

F. Provide cable clamps, compression fittings, and strength member tie-off to support the number of fiber cables that will be terminated in the FDP.

G. FDP Dimensions: 17.2 inch W by 17.8 inch H by 6.2 inch D.
H. FDP to be surface mounted within communications interface terminal cabinets (ITC), located within station TPSS rooms.

2.05 OPTICAL FIBER PIGTAILS, PATCH CORDS, AND CONNECTORS

A. FDP Fiber Pigtails.
   1. Single-Mode Pigtails with SC connector at one end and the other bare jacketed fiber.
   3. Insertion Loss: Maximum 0.20 dB.
   4. Return Loss: Maximum minus 55.0 dB
   5. Pigtail length shall be sized per field install conditions for each FDP location, 3 meter minimum.
   6. Pigtail fibers shall be provided in bundle of up to 12 fibers, individually jacketed with a 900um tight buffer, color-coded in accordance with TIA/EIA 598 Fiber Optic Color Code.
   7. Pigtail fibers shall meet the same physical and optical characteristics of the fiber cable strands that it will be spliced to.

B. Manufactured Fiber Cable Pigtail Assemblies.
   1. A manufactured Pigtail assembly may be utilized to provide connectivity from a FDP to a separate field splice enclosure, such as a fiber splice case located in a communications manhole. The assembly shall allow the connection of FDP’s to fiber a cable backbone cable via a drop cable assembly. Splicing of the drop cable to the mainline backbone cable shall be performed within the splice case. When utilizing a fiber cable pigtai assembly, FDP tray splicing is not to be done.
   2. The manufactured pigtail assembly shall be constructed so as to be installed in conduit, and shall meet the fiber cable requirements as specified within this contract.
   3. Manufactured Pigtail assemblies shall be designed, ordered, pretested, for the specific location that it will be utilized. Excessive cable length in the assembly shall not be permitted.
   4. Cable Loop: Maximum 20 feet.

C. Fiber Patch Cords.
   1. Fiber patch cords shall be cable assemblies consisting of flexible with SC compatible connectors. Patch cords shall be complete factory fabricated assemblies from manufacturer’s standard products lines.
   2. Provide fiber patch cords as required for the following applications:
      a. From port to port within same FDP, for fiber cross-connection patching.
      b. From Network switch equipment optical ports to FDP, to support Link Communications Networks deployment, for both TCN and EFN[SH29][MK30]. Coordinate with Sound Transit IT department.
3. **Single-Mode Duplex Zip cord type**
   a. Manufacturer: Provide by company ADC, Krone or approved equal. \[SH31\][MK32]\n
4. Patch Cord Cable Construction: Shall allow for small bend radius for installation in space-constrained areas. Shall contain a dielectric strength member and a protective outer jacket.

5. Patch Cord Jacket Color: Yellow for single mode.

6. Connector shall be SC UPC (blue) for FDP ports, connector ends for field equipment shall match equipment optical port configuration. Typically LC for Ethernet switches.

7. Coordinate with system equipment installer for final fiber patch cord connector requirements.

8. Patch cord optical fiber shall meet the same characteristic requirements of the distribution panel terminated cable to which it mates.

9. Patch cords installed within ladder tray and at conduit to equipment transitions shall be installed in flexible corrugated innerduct for protection.

### 2.06 OPTICAL FIBER TEST EQUIPMENT

A. Provide Optical Fiber Cable Testers to meet all the requirements for fiber cable testing per contract document.

1. Provide by company Exfo, Fluke or approved equal. \[SH33\][MK34]\n
2. **Optical Loss Test Set (OLTS) Specifications.**

<table>
<thead>
<tr>
<th><strong>Power Meter</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement range (dBm)</td>
<td>+10 to -70</td>
</tr>
<tr>
<td>Wavelength range (nm)</td>
<td>800 to 1650</td>
</tr>
<tr>
<td>Display resolution (dB)</td>
<td>0.01</td>
</tr>
<tr>
<td>Recommended recalibration period (years)</td>
<td>3</td>
</tr>
<tr>
<td>Measurement-distance units</td>
<td>Km, m, Kft, ft, mi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Single Mode Light Source</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelengths (nm)</td>
<td>1310 ± 20/ 1550 ± 20/ 1625 ± 10</td>
</tr>
<tr>
<td>Emitter type</td>
<td>Laser</td>
</tr>
<tr>
<td>Minimum output power (dBm)</td>
<td>-1/-4/-7</td>
</tr>
<tr>
<td>Spectral width (nm)</td>
<td>≤5/≤5/≤5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Automated Test Functions</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelengths (nm)</td>
<td>1310 / 1550 / 1625</td>
</tr>
<tr>
<td>Loss range (dB)</td>
<td>56</td>
</tr>
<tr>
<td>Loss Precision (repeatability) (dB)</td>
<td>0.25 (for loop back)</td>
</tr>
</tbody>
</table>
Automated Test Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length measurement range (km)</td>
<td>200</td>
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<tr>
<td>Length measurement uncertainty</td>
<td>± (10m + 1% length)</td>
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<tr>
<td>ORL range (APC/UPC) (dB) all SM wavelengths</td>
<td>65/55</td>
</tr>
<tr>
<td>ORL uncertainty (dB)</td>
<td>±0.5</td>
</tr>
<tr>
<td>Resolution (dB)</td>
<td>0.01</td>
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<tr>
<td>Store reference power measurement</td>
<td></td>
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<tr>
<td>Save at least 100 results in internal memory</td>
<td></td>
</tr>
<tr>
<td>PC interface (USB)</td>
<td></td>
</tr>
<tr>
<td>Rechargeable Li-Ion battery for 8 hours of normal operation</td>
<td></td>
</tr>
</tbody>
</table>

3. Optical Time Domain Reflectometer (OTDR) Specifications.

**OTDR Single Mode**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength range (nm)</td>
<td>1310 ± 20/ 1550 ± 20/ 1625 ± 10</td>
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<tr>
<td>Dynamic range 10 µs² (dB)</td>
<td>41/39/38</td>
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<tr>
<td>Dynamic range 20 µs² (dB)</td>
<td>42.5/40.5/39.5</td>
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<tr>
<td>Event dead zone (m)</td>
<td>3/3/3</td>
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<tr>
<td>Attenuation dead zone (m)</td>
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</table>

**General Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance range (Km)</td>
<td>1.25, 2.5, 5, 10, 20, 40, 80, 160, 260</td>
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<tr>
<td>Pulse width (ns)</td>
<td>10, 30, 100, 275, 1000, 2500, 10000, 20000</td>
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<tr>
<td>Linearity (dB/dB)</td>
<td>±0.05</td>
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<tr>
<td>Loss Threshold (dB)</td>
<td>0.01</td>
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<tr>
<td>Loss Resolution (dB)</td>
<td>0.001</td>
</tr>
<tr>
<td>Sampling Resolution (m)</td>
<td>0.08 to 5</td>
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<tr>
<td>Sampling points</td>
<td>Up to 52000</td>
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<tr>
<td>Distance uncertainty (m)</td>
<td>±(1+0.0025% x distance)</td>
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<tr>
<td>Measurement time</td>
<td>User-defined (60 min maximum)</td>
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<tr>
<td>Real-time refresh (s)</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Stable source output power (dBm)</td>
<td>-5</td>
</tr>
<tr>
<td>Visual fault locator</td>
<td>Laser, 650±10nm, max pwr 800µW</td>
</tr>
</tbody>
</table>

**Internal 60GB Hard Drive with G-shock protection, 2GB Flash USB drive.**

**Touch screen display color TFT, 800 x 600 TFT**

**PC interface (USB), Serial, Ethernet**

**Rechargeable Li-Ion battery for 8 hours of normal operation**

**Additional Test Modules Support**

- **PMD**- Polarization Mode Dispersion Analyzer supporting TIA/EIA-455-124
- **CMD**-Chromatic Dispersion Analyzer supporting TIA/EIA-455-175B
2.07 INNERDUCT

A. Constructed of flame retardant PVC material and shall meet the following flammability requirements:

1. Inside building horizontal ladder tray, and inside building riser inner duct shall meet the UL 224 flame test.

2. Outside Plant (OSP), Inner duct installed in tunnel or air plenum environment shall be halogen-free, meet BSR/UL 224, and NFPA 130.

3. Station Equipment Room Cable Tray Innerduct.
   a. Inside building horizontal/cable tray innerduct suitable shall be flexible corrugated type.
   b. Utilize corrugated horizontal innerduct for fiber optic patch cords installed from systems equipment to fiber distribution panels.
   c. Inner Diameter: 1 inch minimum, compatible with fiber patch cords installed within.
   d. Manufacturer: Provide by company Carlon, Pyramid, or approved equal.

2.08 IDENTIFICATION TAGS

A. Material: Plastic, heat-shrinkable radiation cross-linked, thermally stabilized, flame-retarded modified polyolefin sleeves.

B. Label: List device or terminal block destination and origin, and cable number. Utilized Sound Transit Link System Station Identifier and existing fiber cable label scheme.

C. Sleeves: Smear resistant prior to shrinking, achieve mark permanency when shrunk without the need for permatizing equipment, or when standard ballpoint pens or high-carbon content fabric ribbons are used.

D. Chemical Resistance: Resistant to common industrial fluids including but not limited to, Freon TF, isopropyl alcohol, and Ethylene Glycol.

2.09 FIBER CABLE FACTORY TESTS

A. Provide certified test reports for each fiber cable type, per the following standards:

1. NFPA-130.

2. Telcordia GR-20-CORE.

3. EIA-455-B


5. NES 711/713 smoke/toxicity index.

6. UL 910.
B. Factory Production Tests: Provide certified test reports for each cable on-reel prior to shipment. These tests shall be performed in accordance with TIA/EIA-455-B.

1. Record end to end loss for each fiber at 1310 nm and 1550 nm for single mode.
2. Provide OTDR trace with both soft trace file, and hardcopy record for each fiber strand.
3. Record cable footage, in accordance with markings and in accordance with OTDR trace.

PART 3 - EXECUTION

3.01 INSTALLATION PLAN

A. Develop a written cable installation procedure and check-off list for approval prior to cable installation in accordance with TIA/EIA 568-B.1 and TIA/EIA-569A.

B. Submit information for each segment of cable to be installed.

C. Site Verification.

1. Verify cable lengths through field verification.
2. Prior to installation, verify conduits, inner ducts, and general site conditions are suitable for the installation of cables and equipment. Verify conduit size, conduit fill, conduit bend radii, manhole spacing, manhole size, raceways, ducts, and associated hardware are proper for the intended installation.
3. Verify required cable length for each cable run prior to installation. Civil stationing appearing on referenced drawings may be used for defining locations and estimating cable lengths. Do not use existing drawings to determine final lengths and cuts. Determine actual lengths by making on-site inspections and measurements.
4. Verify installation design is correct and adequate for cables to be installed.

D. Provide installation plan based on site verification activities and in accordance with Section 01 12 16[SH37][MK38], Work Sequence.

E. Fiber Cable Installation Work Plan to include but not be limited to:

1. Pulling or blowing fiber cable into duct-banks, conduit, and innerduct.
2. Installing and dressing cable into ladder trays, fiber racks/cabinets, and fiber terminal equipment.
3. Splicing fiber cable in FDP fiber panel splice trays.
4. Site Location: Describe and diagram installation area.
5. Provide list of Materials and Equipment to be installed and used.
6. Chronological Plan: List order of cable installation, including estimated time for each cable pull.
7. Plan must indicate a reasonable average time period to perform each task.
8. Pulling Layout: Provide distances and pull tension calculations for each fiber cable at each section of installation.

9. Installation Methods: Use least damaging installation method to install cables in order to ensure maximum cable life and maintainability.

10. Innerduct: Where specified and where practical use innerduct within larger ducts to: optimize conduit usage, prevent damage to cable, and allow for fiber blowing installation methods. Innerduct must be compatible with fiber cable installed within.

11. Slack Cable: Design installation with 50-foot slack coils at either end of cable run, and at splice locations.

12. Bend Radius: Minimum 10 times the diameter of cable or manufacturers' recommended minimum bending radius, whichever is greater.

13. Set Up and Pull Locations: Protect cable on reel and in slack loops. Protect cable after working hours where cable installation is not completed during a single shift.

14. Pull/Blowing Lengths: Allow a 20 percent margin in cable tensile strength. Do not exceed the lesser of 80 percent of the cable's maximum tensile rating or 600 pounds during installation. Identify assist points for blowing cable.

15. Maximum Vertical Rise: Calculate distance over which cable is self-supporting. Provide cable strain relief at top of each vertical rise and every time 80 percent of vertical rise rating of cable is exceeded.

16. Dynamometer: If a winch or pulling machine is used during installation, use a dynamometer to monitor cable tension. Provide pulling equipment and tension monitoring device list.

17. Drawings: Provide a detailed cable plan for each cable pull.

18. Provide proper procedures for feeding cable into conduit, to maintain proper bend radii and minimize friction.

19. Innerduct: Provide innerduct compatible with fiber optic cable installed within.

F. Contacts: Provide company name of installer, and name and contact information (cell phone) of site supervisor to Resident Engineer.

3.02 FIBER CABLE INSTALLATION

A. General:

1. Provide cable as indicated in the Contract Drawings.

2. Install cable in accordance to submitted installation plan.

3. Provide Resident Engineer 48 hours notice prior to installing cables.

4. Cable Installation within Duct banks: Install cable in SC conduits as shown on Contract Drawings. If field conditions prohibit the use of the Sound Transit designated duct, select a duct for use and coordinate selection with Resident Engineer prior to cable installation.
5. Installation Methods: Utilize the least damaging installation method to install cables in order to ensure maximum cable life and maintainability. Preferred methods shall include:
   b. Cable Pulling – Hand Pull, or Winch and Capstan methods.
   c. Cable Laying – In cable trays.

6. Use of Innerduct: Provide inner duct within larger ducts to optimize conduit usage and prevent damage to cable both in current installation and in future installations. Provide smooth-wall/ribbed innerduct to reduce friction. Apply Pneumatic couplers during cable blowing installation methods.

7. If existing communication cables are already installed within a duct without innerduct, pull new cable into duct (also without innerduct) alongside existing cables, provided that the new cable can be pulled without damage to itself or to other existing cables already in place.

8. Conduit fill ratio for all cable pulls in ducts is not to be exceeded.

9. Material and workmanship shall be of the highest quality assuring durability for minimum life expectancy of 40 years.

10. Replace cables damaged during installation at no cost to Sound Transit.

11. Provide conduit to connect Sound Transit furnished raceways to equipment, enclosures, and devices.

12. Provide installation hardware to route, support, terminate, and protect cable installation.

13. Provide service loops sufficient for maintenance and free movement of attached electrical equipment.

14. Vertical Rise: Ensure no residual tension remains on cable after installation except due to cable weight in a vertical rise.

B. Installation in Conduit or Ducts.

1. Inspect, mandrel, swab, and clean conduits and ensure a clean, smooth, concentric interior surface prior to cable installation.

2. Before any wire or cable is pulled into a conduit, a ball, the diameter not less than 85 percent of the nominal diameter of the conduit, shall be pulled through the conduit from one end to the other.

3. If any one of the existing ducts mandrelled in accordance with these specifications is obstructed so that more than 60 minutes is required in attempting to clear the obstruction in a length of duct between adjacent manholes, bring the obstruction to the notice of the Resident Engineer. The Resident Engineer shall verify the duct obstruction and notify the Contractor to proceed with one of the following:
   a. Rod obstructed duct.
   b. Utilize alternate duct.
c. Remove unused cable from duct and rod duct.

d. Install cable by alternate method.

4. Clean manholes and determine location of pulling eyes prior to cable installation.

5. Use lubrication when pulling cables into conduit, pipe, or duct bank.

6. Avoid crossover of cables pulling cables.

7. Do not pull tight or kink cables in conduit fittings or boxes.

8. Pull cables installed in a single conduit simultaneously.

9. Fiber optic cable pulling equipment shall include a dynamometer to indicate the pulling force in pounds.

10. Pulling force shall not exceed 550 pounds or 90 percent of the maximum allowable installation tension as specified by the fiber optic cable manufacturer whichever is the least.

11. When utilizing pulling methods, the pulling speed of the fiber optic cable shall not exceed 20 meters/minute.

12. Any excess slack between a winch and the cable reel must be taken up slowly. Maintain an even speed ensuring constant turning of cable reel without surging or jerking.

13. Continuously monitor cable tension with dynamometer or approved equal during cable pull.

14. Dynamometer: Certify dynamometer as calibrated and able to hold peak value of cable pull. Record peak pull value and submit as part of test results.

15. Fit conduit ends with plastic bell ends.

C. Air-Assist Cable Jetting.

1. Utilize air assisted cable jetting methods for fiber cable installation, within sealed continuous innerducts.

2. Install innerducts as needed for proper Air-Jetting installation of fiber cable, utilize existing innerducts where available.

3. Verify proper installation of innerduct system utilizing pressure tight duct splice fittings, in accordance with innerduct manufacture requirements.

4. Perform duct pressurization test, by sealing one end of the duct and pressurizing the duct using a sealed blowing machine.

5. Clean, dry, and prove the duct. If it was not done previously, blow through a hard mandrel to establish that the duct is not crushed.

6. Blow a tight fitting foam carrier through the duct at high pressure. The foam should travel through at approximately 100 foot/second in a clean duct. If excess water or dirt comes from the duct, repeat the process. If necessary, dry the duct with dry airflow.
D. Installation Field Conditions.
1. Pump water out of manholes or other enclosures before installing any cables.
2. Pumping water out of manholes and removal of mud, silt and debris, if required, shall be done by the Contractor, at Contractor’s expense.
3. Provide the necessary power and pumping equipment.
4. Keep manholes or other enclosures or ducts clear of water during cable installation.
5. Water in manholes and handholes to be handled in accordance with state and local regulations, at Contractors expense.

E. Special Protection.
1. Secure fiber cable slack, and splice cases to wall of manhole on approved cable tracking device. Fiber optic cable and enclosures must be properly secured in a manner which will not obstruct the installation of future communications cables within the manhole.
2. Provide appropriate special protection for cables in areas where cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment.
3. Protect fiber optic cables during installation while cables are exposed in-between work shifts.
4. Replace, at no additional cost to Sound Transit, any existing or new cable which is damaged as a result of failure to provide such special protection.

F. Sealing.
1. Seal cable entrance openings in equipment enclosures, rooms, and junction boxes with either a compression type fitting or pliable sealing compound after the cable is in place.
2. Use sealing compound seal area around cable where cable emerges from conduit, pipe or duct bank. Seal or cap spare conduits.

G. Installation in Trays or Troughs.
1. Lay cable loosely, neatly, and with a minimum of crossovers.
2. Do not pull cable in trays or troughs.
3. Do not pull tightly around bends.
4. Install dividers to segregate cables of different media types.
5. Route cables between racks or cabinets in overhead cable trays.
6. Provide one foot of slack between the cable tray and each rack to which the cable is connected.
7. Secure cable to last strap of cable tray before transitioning to equipment racks or cabinets.
3.03 INNERDUCT INSTALLATION

A. General: Install inner duct in each conduit as indicated on the Contract Drawings. Where multiple inner ducts are required in one conduit, pull innerducts at the same time.

B. Pull Rope: Install in each inner duct, double back 2 feet of pull rope at each termination.

1. Install pull rope or cable having a minimum tensile strength of 225 kg (500 pounds).

2. Double back 600 mm (2 feet) of pull rope at each termination.

3. The use of nylon rope for pulling cable is prohibited.

C. Couplers:

1. Use couplers to mechanically and pneumatically connect two pieces of innerduct without reducing the inside diameter of the inner duct.

2. Install lubricated pull tape or line in unused inner duct.

3.04 FIBER SPLICING AND TERMINATION

A. Splicing shall be completed in optic termination panels with splicing trays as indicated on the Contract Drawings, and per approved splicing procedure.

B. Supply materials required for fiber optic splicing, including but not limited to:

1. De-Natured Alcohol.

2. Fusion Splice Protection Sleeve.

3. Velcro cable ties.

4. Labels.

5. Sealing Tape.

C. Splicing shall be completed using fusion-splicing equipment. Protect individual splices with a reinforced heat shrink sleeve affixed to splice tray.

D. Splice Trays: Firmly mount into outdoor rated splice enclosure or into cabinet mounted splice enclosure as shown on Contract Drawings.

E. Minimum 2 feet (610 mm) of bare fiber shall be coiled and stored in the splice tray in a protected manner. Plastic Cable ties may not be utilized to directly secure exposed bare fiber.

F. Minimum 3 feet (914 mm) of each buffer tube in the fiber optic cable shall be coiled and stored in the splice enclosure or distribution panel.

G. Properly fasten cables to prevent against pulling out of the splice enclosure or distribution panel. The fiber cable central strength member shall be attached to the FDP, the outer jacket of the cable shall be attached to the FDP with a cable clamp. All securing hardware shall be in accordance with FDP manufactured supplied kits and instruction.

H. All fiber optic splices shall be fusion splices. Splices shall be stored within FDP or Splice Case splice trays for the purpose of passing optical connections to FDP pre-connectorized pigtail assemblies, or to an additional OSP fiber cable.
I. Fusion splicing shall be performed by qualified personnel utilizing a splicer equipped with Local Injection Detection (LID) to optimize splices. Maximum Splice Loss Attenuation: max 0.1dB at 1310, 1550, and 1625nm.

J. Fusion Splicing equipment shall be capable of working on battery power. Provide spare battery units when no local power source is available.

K. Terminate fibers with factory polished pre-connectorized pigtails.

L. Location: Splicing shall be within Fiber Distribution Panels, and Splice Case Enclosures.

M. Fusions splice pigtails shall be labeled with the fiber number using a pre-printed vinyl number tag.

N. Splice trays shall be labeled including fibers spliced in the tray. Cables at each location shall be designated with the next termination point at the other end of the cable.

O. Design and maintain splice trays as re-enterable.

P. Loop-through splicing shall be used at locations as shown on contract drawings in lieu of dedicated cables to a served location. In loop-through splicing, only the fiber strands branching off from the main cable to enter a communication room site are cut and spliced. The other fibers are not cut. The jacket is cut from the cable exposing the buffer tubes, fibers being “dropped” are cut and spliced, the remaining fibers are carefully dressed within the splice case (not cut) and continue out of splice case.

Q. For fiber optic cables that are the 900um tight buffered designed specifically for direct field connectorizing, install field connectors in accordance with manufacture instruction, utilizing manufacture supplied tools. Prior to field installation. Demonstrate to Resident Engineer for approval, proper installation of field installable type fiber connectors.

R. Notify the Resident Engineer in writing at least 2 weeks in advance of terminating each section of optical cable.

3.05 CABLE IDENTIFICATION

A. Tag cables at the following locations:

1. Termination points.
2. Fiber Distribution Panels.
3. Where cable enters or exits Communications Rooms, manholes, handholds, and housings.
4. On each side of barriers the cable passes through.
5. At aerial exits from conduit risers.
6. Innerducts within handholes/manholes that contain cables must be tagged to indentify cables that are within.

3.06 FIELD TESTING-GENERAL

A. Demonstrate the functionality of the installed system through testing as specified below and in accordance with Section 01 95 019, System Testing and Integration.
B. Tests shall be conducted in accordance with an approved test plan that shall cover the key functional requirements of the Work.

C. Provide suitable test equipment, instruments and labor for the purpose of tests.

D. Test shall be performed after installation is complete.

E. Provide sufficient notice of not less than 5 Working Days prior to the commencement of testing. Submit with this notice a schedule of all tests covered by this notice. A Resident Engineer representative shall be invited to witness each field testing event.

F. Optical Attenuation and OTDR testing shall be recorded: from FDP to FDP (both Inter and Intra station), and for Radio Cabinet fiber cable connector link between stations.

G. All Attenuation and OTDR testing shall be done bi-directionally on each strand. For Fiber Cable strands that are dedicated for future terminations as part of Link expansion, temporary fiber pigtail connectors shall be spliced to bare strands as required for the purpose of bi-directional testing.

H. All fiber optic strands shall be tested in accordance with the field tests specifications defined by the TIA/EIA-568-B.1-2.

I. TIA/EIA-568-B.1-2, shall be used to define the passive cabling network, to include cable, connectors, and splices (if present), between two Fiber Distribution Panels (connecting hardware). This TIA/EIA document shall be used to describe all applicable link segments.

J. All of fiber cabling links installed shall be tested and shall pass the requirements of the standards mentioned above, including patch cords after they have been installed between equipment and FDP. Any failing links shall be diagnosed and corrected prior to system acceptance. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. Final passing results of tests for all links shall be provided in the test results documentation.

K. Fiber optic technicians shall be qualified and have obtained a certificate, as proof thereof to execute all fiber optic testing. Certificates may have been issued by any of the following organizations or an equivalent organization.

1. The manufacture of the fiber optic cable or connectors.

2. The manufacture of the test equipment used for the field certification.

3. Training organizations authorized by BICSI (Building Industry Consulting Services International).

L. Field test instruments for single mode fiber cabling shall meet the requirements of TIA/EIA-526-7A-B.

M. Test instrument calibration date shall be within the calibration period recommended by the vendor in order to achieve the vendor specified measurement accuracy.

N. Fiber optic test launch cables and adaptors shall be of high quality and the cables not show excessive wear resulting from repetitive coiling and storing of the test instrument interface adaptors.

O. Prior to testing, all fiber optic connectors and bare fiber ends are to be properly cleaned using a residue free alcohol solution (better than 91 percent de-natured alcohol and distilled water) and compressed air.
3.07 FIELD INSTALLATION TESTING

A. Pre-Installation Testing.

1. Pre-installation tests shall be conducted on the cable reels after shipment to but prior to installation. These tests shall be performed in accordance with TIA/EIA-455-B.

2. Verify fiber strand continuity and cable length for fiber cables on shipment reel, verify cable length with printed footage marking on cable jacket. Verify Buffer tube construction and fiber strand count.

3. Provide OTDR trace at 1550 nm, with both soft trace file, and hardcopy record for each fiber strand.

B. Fiber Cable Plant Testing- Attenuation Loss.

1. In compliance to TIA/EIA-568, the performance parameter for field testing of fiber optic links shall be link attenuation (insertion loss).

2. Link attenuation shall be calculated by the following formulas as specified in ANSI/TIA/EIA 568:
   a. Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation.
   b. Cable Attenuation (db) = Attenuation Coefficient (db/km) x Length (km).
   c. Connector Attenuation (db) = number of connector pairs x connector loss (db). Maximum allowable connector loss = 0.75 db.
   d. Splice Attenuation (db) = number of splices (S) x Splice loss (db). Maximum allowable splice loss = 0.2 db.
   e. The maximum values for the Attenuation Coefficient are listed below:
      1) Single mode fiber cable (outside plant), 1310 nm: 0.5 db/km.
      2) Single mode fiber cable (outside plant), 1550 nm: 0.5 db/km.
   f. Link attenuation shall not include any active devices or passive devices other than cable, connectors, and splices.
   g. Test equipment that measures the link length and automatically calculates the link loss based on the above formulas is preferred.
3. In the above link test parameters, attenuation is based on the use of the One Reference Jumper Method specified by TIA/EIA-526-7, Method A.1; or the equivalent method. The tester shall follow the procedures established by these standards or application notes to ensure accuracy of tests results.

4. Single-mode fiber links shall be tested at 1310 nm and 1550 nm in accordance with TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method. Single-mode links shall be certified with test tools using laser light sources at 1310 nm and 1550 nm.

C. Fiber Cable Plant - (OTDR) Testing.

1. Fiber Optic Testing utilizing an Optical Time Domain Reflectometer (OTDR) shall adhere to the following specifications: TIA/EIA 455-78, TIA/EIA 455-133.

2. OTDR Acceptance Testing: Fiber Links and Splices:
   a. OTDR testing to be completed on each section of the fiber network after splicing is completed.
   b. A fiber link shall be defined as a continuous section of fiber from connector to connector that may pass through a number of intermediate splices.
   c. Test each fiber link in the cable at 1310 nm and 1550 nm (for single-mode) operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
   d. Use a dedicated “launch-cable” patch cord of sufficient length to ensure that start of the fiber under test is not in the “dead zone” of the OTDR. The first connector of the link under test shall be visible on the trace.
   e. Optical Return Loss (ORL) for each link shall be measured.
   f. Fiber link length shall be measured.
   g. Test Results:
      1) Reflective events shall not exceed minus 40 dB.
      2) Connections shall not exceed 0.75 dB of attenuation.
      3) Non-reflective events (splices) shall not exceed 0.2 dB (bi-directional average). Fusion splice losses in excess of 0.2 dB requirement shall be re-spliced and re-tested until compliant at the contractors expense. Deviations from maximum splice loss may be approved by Resident Engineer on a per splice basis.
      4) Point discontinuities shall not exceed 0.1 dB.
      5) ORL shall be less than minus 30 dB.
   h. OTDR Test results shall include OTDR link and channel traces and event tables at the required wavelengths, and the length for each optical fiber as calculated by the OTDR.
3.08 FIELD SYSTEM TESTING - FIBER SPAN CHARACTERIZATION

A. General Requirements.

1. Perform fiber optic Characterization testing on 10GigE and GigE Inter-station fiber strand links.

2. For traffic carrying 10GigE or GigE Links, Fiber Characterization Testing shall be from equipment node patch cord to equipment node patch cord and include all intermediary FDP fiber patch cross-connections that make up the full optical path of the link under test.

3. These Fiber Characterization Tests are in addition to the General Fiber cable strand testing required for fiber cable strands (active and dark).

4. Fiber characterization is defined as a series of tests taken on a fiber optic span to determine the integrity of the fiber, installed practices, and performance for a desired transmission rate (1Gb/s or faster) and or Service to be implemented (DWDM). Fiber Qualification tests:
   
a. Optical Return Loss (ORL): 1550nm wavelength from both fiber ends.
   
b. Optical Loss Test Set (OLTS): End to end Insertion Loss at 1550nm & 1625nm wavelengths, bi-directionally averaged.
   
c. OTDR: 1550nm & 1625nm wavelengths, bi-directionally averaged.
   
d. Polarization Mode Dispersion (PMD): 1550nm wavelength, single ended.
   
e. Chromatic Dispersion (CD): 1520nm to 1630nm at 10nm wavelength increments, single ended.

B. ORL and Optical Loss Test Parameters.

1. Required fiber spans shall be tested with optical power meter and light source combination. ORL measurements shall be conducted at 1550nm only. The loss results must be conducted at 1550nm and 1625nm and include measurements for:
   
a. ORL results from A to B and B to A.
   
b. Actual loss of the fiber span under test from A to B and B to A.
   
c. Average bi-directional loss of the fiber span under test.

2. All loss readings must be within calculated loss budget for link under test. Exceptions must be communicated to Resident Engineer prior to leaving test location. Fiber test contractor to recommend corrective action that will resolve any span test exceptions prior to use by network equipment. ORL and Optical loss reports to be submitted as part of final report to Resident Engineer for approval.

C. OTDR Test Parameters.

1. Required fiber spans shall be tested with an OTDR. The OTDR tests must be conducted at 1550nm and 1625nm and include measurements for:
a. Total end to end average loss (bi-directionally) of fiber under test.
b. Total length of fiber span under test.
c. Average loss (bi-directionally averaged) of each splice in the fiber span under test.
d. Reflectance and average loss of each connector in the fiber span under test.

2. Bi-directional OTDR reports shall be generated with the OTDR manufacture’s software. Fiber spans must meet calculated test threshold criteria. Exceptions must be communicated to Resident Engineer prior to leaving test location. Recommend corrective action that will resolve any span test exceptions prior to use by network equipment. OTDR test reports, including raw trace files to be submitted as part of final report to Resident Engineer for approval.

D. Dispersion Test Parameters (PMD and CD).

1. Polarization Mode Dispersion (PMD) results must be conducted at 1550nm (broadband) and include:
   a. PMD results for fiber span under test (in ps).
   b. PMD coefficient result for the fiber under test (in ps/√km).
   c. Pass / Fail indication for the fiber under test.

2. Chromatic Dispersion (CD) measurement tests are conducted across the spectral range from 1520nm to 1630nm at 10nm increments. Include results for:
   a. Zero dispersion point for fiber under test (in nm).
   b. Dispersion at wavelengths to be transmitted (in ps/nm).
   c. Dispersion normalized to the length of the fiber span under test (in ps/nm-Km).

3. PMD and CD results to be generated by equipment manufacture software. Test results must be span thresholds per Link bit rate speeds. Fiber test contractor to recommend corrective action that will resolve any span test exceptions prior to use by network equipment. PMD/CD test reports to be submitted as part of final report to Resident Engineer for approval.

E. Fiber Characterization Test Acceptance Criteria.

1. Attenuation Threshold.

<table>
<thead>
<tr>
<th>Splice/Connector Specifications</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Splice Loss (bi-directional) (ea) (max)</td>
<td>0.20dB</td>
</tr>
<tr>
<td>Connector Loss (ea) (max)</td>
<td>0.50dB</td>
</tr>
<tr>
<td>Connector Reflection</td>
<td>UPC: -50dB, APC: -55dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fiber Attenuation Guidelines</th>
<th>Attenuation (dB/Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Max loss budgets (in dB) will be determined by:

\[(\text{Length in km} \times 0.25) + (\#\text{connector pairs} \times 0.5) + (\#\text{splices} \times 0.2)\]

2. ORL Threshold: ORL results will be 27dB or greater for both 1550 nm and 1625 nm

3. PMD Threshold: Based on industry standards and are specific to the transmission rate of the network system.

<table>
<thead>
<tr>
<th>PMD Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bit Rate</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>2.5 Gb/s</td>
</tr>
<tr>
<td>10 Gb/s</td>
</tr>
<tr>
<td>40 Gb/s</td>
</tr>
</tbody>
</table>

4. CD Threshold: Based on industry standards and are specific to the transmission rate of the network system.

<table>
<thead>
<tr>
<th>CD Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bit Rate</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>2.5 Gb/s</td>
</tr>
<tr>
<td>10 Gb/s</td>
</tr>
<tr>
<td>40 Gb/s</td>
</tr>
</tbody>
</table>

5. Fiber Characterization Test Results.
   a. Test procedures and results shall be documented precisely and complete reports shall be provided to the satisfaction of the Resident Engineer.
   b. Based on field test results, a detailed fiber span analysis report with recommendations identifying the transmission capabilities shall be generated. Links under test must support the GigE or higher transmission speeds suitable for MPLS Network backbone links.
   c. Submittals shall include, but are not limited to, test plans and procedures, pass/fail criteria for each link, the forms for recording of test and test results including test witness signature areas, results analysis and recommendations.

3.09 CABLE PLANT TEST RESULT DOCUMENTATION

A. The test result information for each link shall be recorded in the memory of the field test equipment upon completion of the test.

B. The test result records saved by the test instrument shall be transferred into a Windows-based database utility that allows for the maintenance, inspection and archiving of these tests records. Test results must be transfer to PC unaltered.
C. Test results must be turned over to the test witness at the end of each testing work shift. The fiber testing technician must provide the stored OTDR trace files of the fibers under test via a USB output port for transfer to a portable USB flash thumb drive. The OTDR trace file results shall be in an electronic format to allow Resident Engineer to view the trace files utilizing standard OTDR trace file viewer software.

D. OTDR traces shall be recorded in suitable electronic format. OTDR vendor approved software tools and applicable licenses required to view, inspect, sort, and print the OTDR traces shall be provided to Resident Engineer at no additional charge.

E. Expand the vertical and horizontal scales used on the OTDR to maximize the amount of detail shown on the OTDR trace, even if these parameters can be adjusted later using display software.

F. Ensure that traces identify the end points of the fiber under test and the fiber designation. If this information is not provided by the trace itself, provide a cross-reference table between the stored trace file name and the fiber designation.

G. A paper copy of the test results shall be provided that lists the links that have been tested with the following summary information:

1. The Identification of the link in accordance with the optical fiber cable naming convention defined in the overall system documentation.
2. The overall Pass/Fail evaluation of the link under test including the attenuation worst-case margin (margin is defined as the difference between the measured value and the test limit value).
3. The date and time the test results were saved to the test equipment memory.

H. General information shall be provided in the electronic database containing the fiber test result information for each link:

1. Identification of the site.
2. Overall Pass/Fail evaluation of the link under test.
3. Name of the standard selected to execute the stored test results.
4. Fiber cable type and the value of the 'index of refraction' used for length calculations.
5. Date and time the test results were saved to the test equipment memory.
6. Model, serial number, and calibration date of the optical test equipment.
7. Revision of the tester software and the revision of the test standards database within the tester.

I. Provide detail test results data in the electronic database for each tested optical fiber shall contain the following information:

1. Identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.
2. Insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength and margin (difference between the measured attenuation and the test limit value).
3. Link length shall be reported for each optical fiber for which the test limit was calculated based on the formulas specified herein under Fiber Cable Plant Performance Testing Parameters.

3.10 FIBER OPTIC SYSTEM LABELING

A. Fiber Optic Cable.

1. Fiber optic cable shall be identified whenever entering and exiting a splice enclosure, manhole, cabinet, FDP, pull point/box, and at all FDP terminals.

2. Label fiber cable strand counts that are in each splice tray by affixing a permanent label to surface of splice tray cover.

3. Permanent marking tags fastened securely to the cables shall be used for identification.

4. Cable designation shall consistently conform to the overall Sound Transit labeling scheme, as shown on contract drawings. Labels to be approved by Resident Engineer.

5. Letters and numbers shall be used. Identification shall be made with a clear, machine produced, indelible marking.

B. Innerduct.

1. Innerduct shall be labeled at each end and where it is passed through a vault as "ccc - iii", where ‘ccc’ is the conduit number from the site as-built drawings and ‘iii’ is the innerduct number, within the conduit.

2. Indicate cables that are within a section of innerduct in accordance with above Fiber Optic Cable labeling.

C. Fiber Distribution Termination Panels.

1. Label each termination panel at each termination point for each fiber.

2. Termination labels shall conform to the overall scheme approved by Sound Transit to indicate location, device and next access point.

3. Identification shall be made with a clear, machine produced, indelible marking.

3.11 FINAL INSPECTION

A. Final Inspection will include the following activities:

1. ‘As-built’ drawings and manuals will be examined by Sound Transit for conformance to the Drawings, Codes, Regulations, and General Accuracy. Any variation from specifications will be highlighted.

2. Test results will be reviewed, both electronic and paper copies. Verify supplied fiber cable test database results is complete for cables tested as part of contract.

3. Work will be physically inspected to ensure that work has been completed in accordance with the specifications.
4. Upon completion of final inspection activities, any deficiencies will be recorded. Deficiencies shall be corrected by the appropriate party and will be re-inspected by the Resident Engineer.

5. Final Inspection shall not be deemed complete until deficiencies are corrected.

3.12 SYSTEM SUPPORT

A. Maintenance.

1. Develop a maintenance plan that details preventative maintenance, outage repair, and administration procedures required for systems optical fiber equipment prior to Final Acceptance.

2. List personnel, equipment, and duration required for each procedure developed. Include frequency necessary for preventative maintenance procedures.

B. Test/Maintenance Equipment.

1. Provide test equipment for maintenance and management in order to support fiber cable equipment.

2. Equipment to Include:
   a. Fiber trace viewing application software.
   b. Hand held fiber strand Visual Fault Locator: Wavelength 630-645nm, Emitter type laser, power output 0.6mW, Range 5 km. Pocket Pal, Exfo FLS-240 or approved equal.
   c. Optical Fiber Identifier: Identifies traffic carrying fiber for 200 µm, 900µm, or 3mm jacketed strands/patch cords, identification without traffic disruption, provides indication of strand traffic dBm level. AFL-Noyes OFI-400 or approved equal.
   d. Optical connector ferrule cleaning Kit: Cletop-S Type A (2.5mm – SC-UPC), Blue Tape, or approved equal.

3. Equipment to be turned over to Resident Engineer at Substantial Completion.

C. System Documentation and Record Drawings.

1. Provide in accordance with Section 01 78 39, Project Record Documents.

2. As-Built Documents. Provide the following documents as part of the as-built set:
   a. Cable Plant Test Results documentation in accordance with the above specifications.
   b. Optical fiber cable plant schedule including: Cable ID, cable length, conduit/duct bank installation location, splice locations, fiber distribution panel port and tray terminations locations, patch cord routing.
   c. Drawings: Fiber Plant schematic, Riser diagram, Point to Point fiber strand termination details, Fiber Distribution Panel details.
   d. Final Equipment BOM lists.
3.13 SPARE PARTS

A. Provide spare fiber splice case as specified herein, fully equipped with splice trays, and splice sleeves to support 144 splices.

B. Provide spare SC bulkhead connectors, panels, SC-APC pigtail assemblies, splice trays, and splice sleeves compatible with the Fiber Distribution Panels as specified herein. Provide for a total of 72 spare fiber splice/terminations.

C. Provide spare fiber patch cords for Intra-FDP, FDP to FDP, and equipment to FDP connections as specified herein. Provide number of patch cords equal to 50% of the total of traffic carrying patch cords installed per final acceptance of University Link Station network communications requirements. Patch cords lengths and connector types to be site specific per equipment requirements.

[END OF SECTION][SH43]
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing, and installing a fully addressable fire alarm and smoke detection system and voice evacuation system.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 26 05 26, Grounding and Bonding for Electrical Systems
2. Section 28 31 10 Fire Alarm Speakers

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. National Fire Protection Association (NFPA):
   a. NFPA 70 National Electrical Code

2. International Fire Code Institute (IFC):
   a. Uniform Fire Code (UFC)
   b. International Association of Plumbing and Mechanical Officials (IAPMO)
   c. Uniform Mechanical Code (UMC)

   a. 42 U.S.C. 12181 Americans with Disabilities Act of 1990 (Title III) (ADA)

4. Seattle Fire Department

5. Seattle Fire Code

6. Seattle Department of Design, Construction and Land Use

7. Seattle Electrical Code

8. Seattle Mechanical Code
1.03 SYSTEM DESCRIPTION

A. The system shall provide addressable alarm points including the following:

1. Smoke Spot Detection
2. Heat Spot Detection
3. Water Flow
4. Pressure Switch
5. Tamper Switches
6. Preaction sprinkler system
7. Clean Agent System Alarms
9. Reflective Beam Detectors
10. Linear Heat Detectors

B. Analog Thermal detectors:

1. Shall be provided to detect a high temperature condition in the indicated areas.
2. Thermal detectors shall be located in accordance with guidelines in NFPA 72 or manufacturers UL (or FM, if applicable) listed spacing.
3. Thermal detectors shall not be installed immediately above heating appliances.
4. Thermal detectors, rated as required, shall be provided to detect a high temperature condition in ceiling and roof structure cavities as required by code authority.

C. Photoelectric detectors shall be provided to detect fire conditions in the required areas. Detectors shall be located in accordance with the guidelines of NFPA 72.

D. Reflective Beam detectors and linear heat detectors shall be provided to detect fire conditions in the chamber area. Detectors shall be located in accordance with the guidelines of NFPA 72.

E. A rechargeable battery supply shall be provided to automatically operate the entire fire detection and alarm system, including detectors, control panel, alarm sounding devices, and auxiliary control equipment (unless otherwise specified herein) in the event of a loss of primary power.

F. Audible and visible evacuation alarms shall be provided throughout the station.

G. Serial RS-485 port shall be provided on the Fire Alarm control Panel (FACP) to report all alarms and fire system status to the Central Control System through the Building Management System (BMS).
H. The fire alarm system shall be compatible with the existing fire alarm subpanel installed in the tunnel. A fiber optic communication port shall be provided for connection of an existing subpanel installed in a previous contract. The existing panel is located in the tunnel and shall be connected to the station FACP to allow all alarms and system status to be reported to the Central control system through the BMS.

I. A fiber optic interface port shall be provided on the Fire Alarm Control Panel (FACP) for a future connection to the Fireworks interface console located at the LCC.

J. Fire system status shall be available on a Fireworks workstation installed in the Fire Command Center in the station.

K. Fire system status provided by the interface port shall include all FACP status, alarm and control information including:

1. Individual detector alarms
2. Individual detector malfunction
3. Zone Alarms
4. Manual alarm stations
5. Flow switches
6. Tamper switches
7. Deluge system actions
8. Pre-action systems
9. Clean Agent systems
10. Elevator recall and/or shutdown
11. FACP real time clock
12. FACP system trouble
13. Fire Doors
14. Voice Evacuation System Trouble
15. Paging System Trouble

L. Provide documentation of all status items available. The intent is to fully identify each status item to other contractors for system interoperation and graphical display building.

1.04 SUBMITTALS

A. Refer to Section 01 33 00, Submittals, for submittal requirements and procedures.

B. Shop Drawings:

1. Drawings shall be drawn on 24-inch by 36-inch erasable Mylar or approved. Layout Plan Drawings, Interconnect Drawings, and Wiring Diagrams must have Seattle Fire Department approval prior to submitting to the Resident Engineer. Submitted Drawings shall have Seattle Fire Department approval marked thereon
2. Provide a general layout of the complete system including equipment arrangement. It shall be the responsibility of the fire alarm installer to verify dimensions and ensure compatibility all other systems interfacing with the fire alarm system.

3. Identify on the Drawings; raceway and conductor sizes and types with number of conductors in each conduit. Provide each raceway and device with a unique alphanumeric identification.

4. Indicate on the point to point wiring diagrams, interconnecting wiring within the panel between modules, and connecting wiring to the field device terminals.

C. Interconnect Drawings: Show only external connections between equipment and devices. All wires shall be identified with alphanumeric designators and all termination points shall show the correct terminal identification.

D. Wiring Diagrams: Show the general physical arrangement of the component parts of the equipment and the connection of all internal wiring. All components, wires, terminal strips, and terminals shall be identified with alphanumeric designators.

E. Equipment Mounting Details: Show the mounting location for all floor and wall mounted equipment including distance from floor and column lines, and fabrication details for all special mounting brackets. Details shall also provide any special installation instructions. These details may be included on the Layout Plan Drawings if space allows.

F. Layout Plan Drawings: Show every device provided under this Section in its relative spatial location. Sections and elevations shall be utilized as necessary to accurately describe the installed location of all devices.

G. System Calculations:

1. Provide voltage drop calculations indicating the system ability to furnish power at a minimum of 90 percent of nameplate listing in a standby power condition with all devices in alarm utilizing the proposed wire type and size. Demonstrate that no single wire run between a circuit and its most remote device exceeds the manufacturer’s recommendations for wire length, circuit resistance, or circuit wire to wire and wire to ground capacity.

H. Battery Calculations: Itemize battery loads under standby and alarm conditions. Auxiliary power supplies and transponder battery calculations shall demonstrate the ability of the batteries to supply the required secondary power for a period of 24 hours (or local code requirements) with no external power applied and furnish power for worst case alarm signaling for 5 minutes at the end of this period with all devices in alarm and all device LED's lighted. Battery sizing shall be at a factor of 1.5 times the results of this mathematical requirement to account for battery aging between replacements and for system modifications and expansions. Complete the Fire Alarm Emergency Power Calculation form in NFPA 72 appendix.

I. Voice Evacuation System Calculations: Refer to Section 28 31 10.

J. Equipment Data Sheets:

1. Show the color, configuration and dimensions of the equipment or device described.

2. Provide technical Contract Specifications, such as operating voltage, operating temperature and humidity limitations, mounting and wiring information and a description of the function and operation of the device.
K. Recommended Spare Parts List:
   1. Submit a listing of all devices and components recommended for Sound Transit purchase as spare parts to support the system. The list shall include recommended quantities for all items.
   2. Provide unit price list valid for 90 days after submittal.
   3. Scheduled Testing: The vendor shall include step-by-step procedures and allowances for performance testing every fire alarm device and system output to demonstrate functionality in accordance with specification requirements and Seattle Fire Department requirements.

L. Operation and Maintenance Manuals: Manuals shall contain the following minimum information:
   1. Complete Operating Instructions.
   2. Preventative Maintenance Instructions.
   3. Catalog Sheets on all Devices and Equipment.
   4. Manufacturers Operation and Maintenance Instructions.

M. Record Drawings: At the completion of the installation, provide record drawings to reflect the accurate as-built condition. Working plans shall show actual, accurate locations of devices, and actual routing of conduit and location of end of line devices. The installer shall provide updated as-builts on CADD and two full-size prints of the Record Drawings.

N. Acceptance Test Procedure (ATP):
   1. Submit for approval, prior to testing, an ATP meeting the requirements of this Section and Section 28 31 10.
   2. Submit, for system record, all required data as compiled during installation and testing upon completion of the ATP tests. These data shall be loose leaf bound and labeled as system acceptance testing information.
   3. Submit, for system record, a completed "Fire Alarm System Certification and Description" as included in NFPA 72.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements
   1. "Component Listing: Fire detection and alarm components furnished under this Section shall be UL listed, listed in the Fire Equipment List or FM, approved for fire signaling or fire suppression use. Accessory equipment shall be manufactured with UL listed components.
   2. Conform to the requirements of NFPA 101 and NFPA 72.
   3. Conform to applicable local regulations. Design and installation shall meet the requirements of the Seattle Fire Department.

B. Qualifications
1. Manufacturer: Company specializing in smoke detection and fire alarm systems with 5 years experience.

2. Installer: Company specializing in smoke detection and fire alarm systems with 5 years documented experience and certified by the manufacturer as a fire alarm installing contractor.
   a. Contract shall ensure that Installer evaluates and supplements the design shown in the Contract Drawings as required for proper detection and alarm annunciation consistent with the characteristics of the products he proposes to incorporate into the system.
   b. Contract shall ensure that Installer prepares a design that, in addition to the minimum requirement shown, includes all additional design equipment and installation necessary to obtain Seattle Fire Department acceptance.

3. Warranty: All manufacturer warranties shall be passed on to Sound Transit. Installation shall be warranted for a minimum period of two years after system acceptance.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
   A. Edwards Systems Technology
   B. Notifier
   C. Honeywell
   D. Simplex Systems
   E. Siemens
   F. GE Security
   G. Approved Equal

2.02 MATERIALS
   A. General Requirements
      1. Equipment shall be new and marketed by a single manufacturer. The system shall include equipment, software, firmware, raceways, and wiring as required to provide a complete and operating system in full compliance with these Contract Specifications, Contract Drawings and requirements of the Seattle Fire Department.

   B. Fire-Alarm Control Panel (FACP)
      1. General Requirements for Fire-Alarm Control Panel:
         a. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL. Panel shall be listed for fire alarm and releasing service.
1) System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.

2) Include a real-time clock for time annotation of events on the event recorder and printer.

3) Addressable initiation devices that communicate device identity and status.
   a) Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
   b) Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

4) Addressable control circuits for operation of mechanical equipment.

b. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control panel 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, 2 line(s) of 40 characters, minimum.
   2) Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

c. Circuits:
   1) Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   2) Install no more than 50 addressable devices on each signaling line circuit.
   3) Serial Interfaces: Two RS-232 ports for printers.
   4) Serial Interface: RS-485 port for connection to the BMS.

d. Notification Appliance Circuit: Circuits for strobe and speaker operation. Audible alarms shall include temporal warning tones. Notification Appliance circuits shall interface with the Voice Evacuation system panel.

e. Elevator Recall:
   1) Smoke detectors at the following locations shall initiate automatic elevator recall.
a) Elevator lobby detectors except the lobby detector on the designated floor.

b) Smoke detector in elevator machine room.

c) Smoke detector at top of elevator shaft.

2) Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.

3) Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

   a) Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

f. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

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.


i. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

j. 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.

k. The Fire Alarm Control Panel shall use Edwards EST and Field Server hardware.

C. Fireworks Workstation

A Fireworks workstation shall be provided for local interface to all alarm and status indications. The workstation shall be compatible with existing systems installed at the LCC.
D. System Power Supply
   1. Input Power: 120 volts ac. from UPS.
   2. Secondary Power Supply:
      a. Provide sealed gelled-electrolyte batteries as the secondary power supply for the fire alarm control panel and each system transponder. The battery supply shall be sized to operate the system in a supervisory mode for a period of 24 hours with no primary power applied and at the end of that period operate its alarm mode for a period of five minutes. Batteries shall be sized at 30 percent above the calculated size to compensate for deterioration and aging during the battery life cycle. Batteries shall be housed in the control cabinet or a separate cabinet with adequate cell separation to prevent accidental discharge. If housed in a separate cabinet, a fuse block shall be provided within the battery cabinet.
      b. Provide battery-charging circuitry for each standby battery bank in the system low voltage power supply or as a separate circuit. The charger shall be automatic in design, adjusting the charge rate to the condition of the batteries. Charger shall be housed in the main fire alarm control panel or the battery cabinet. The charger shall be capable of charging the batteries from 75 percent of full charge to 100 percent of full charge within 24 hours.

E. Manual Fire-Alarm Boxes
   1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38 and NFPA 72. 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.
      a. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control panel.
      b. Station Reset: Key- or wrench-operated switch.

F. Analog Addressable Heat Detectors
   1. Rate compensated type, rated at 135 degrees F. Detectors shall be constructed to compensate for the thermal inertia inherent in detectors due to the thermal mass, and alarm at the set point. Detector bases shall be of the twist-lock style and shall be provided with an indicating light to verify operation, which shall latch on in an alarm condition. Removal of the detector from its base shall cause a system trouble signal. Devices utilizing pins, jumpers, or staples are not acceptable.

G. Analog Addressable Smoke Detectors, Photoelectric
   1. Light refraction technology smoke detectors shall have a high rejection of false signals caused by electrical noise and electrical transients and shall be capable of being checked for sensitivity without being removed from its twist-lock base. The reading of the detector sensitivity shall yield a discrete electrical value for
logging and tracking of status to determine the maintenance and cleaning requirements. The detector shall be capable of being readily disassembled to gain access to the detection chamber for cleaning and maintenance. Detectors shall be used for open area protective coverage and shall be insensitive to air velocity.

2. Detector bases are to be low-profile, twist-lock. Bases shall be capable of installation on a 4-inch square or octagonal electrical outlet box. The detector base shall be equipped with an indicating LED that shall flash to indicate system communications and shall change state to a steady "on" when the detector reaches the selected threshold for alarm and communicates that alarm to the system. Removal of the detector from the base shall cause a system trouble condition with and display a distinctive trouble code on the control panel display indicating the zone of the trouble condition.

H. Analog Addressable Duct Detectors

1. Air Duct Smoke Detectors:

a. Sampling photoelectric or ionization type for sensing of products of combustion within the air stream of ducted fan systems. The devices shall include necessary sampling tube extensions and sensitivity adjustments for detection of products of combustion across the width of the duct.

b. The device shall actuate upon nominal 2 percent light obscuration per foot. Visual indication of normal and alarm/trouble shall be incorporated into the exposed surface of the device. Two auxiliary contacts shall be provided for connection to mechanical control system.

2. Detectors shall be approved for use in environments as covered by FM, UL 268a, and UL 268. Detectors furnished shall be available in the following configurations to serve all possibilities:

a. High Velocity: As listed for use in HVAC duct detection applications of air velocities of up to 1200 feet per minute.

b. Low Velocity: As listed for use in HVAC duct detection applications of velocities between 500 and 4000 feet per minute.

3. Detector bases are to be low-profile, twist-lock type with screw clamp terminals and self wiping contacts. A security lock shall be installed in those areas where indicated on the Drawings as requiring tamper resistant installation. Bases shall be capable of installation on a 4-inch square or octagonal electrical outlet box. The detector base shall be equipped with an indicating LED that shall flash to indicate system communications and shall change state to a steady "on" when the detector reaches the selected threshold for alarm and communicates that alarm to the system. The specified LED functions shall indicate detector state whether the system is in the normal mode or the standby power mode. Removal of the detector from the base shall cause a system trouble condition with and display a distinctive trouble code on the control panel display indicating the zone of the trouble condition.

I. Reflective Beam Detectors
1. Single ended intelligent reflected beam smoke detectors with integral sensitivity test feature shall be provided. Detector range shall be up to 300 feet. Detector shall alarm when smoke level between the detector and reflector reaches the predetermined threshold. Threshold shall be field settable.

2. Reflector shall be mounted be adhesive on glass elevator wall. Align detector and reflector in the field for maximum signal strength.

J. Linear Heat Detector

1. Detector Cable: Comply with UL 521. The cable shall be suitable for ambient temperatures up to 150 deg F. The alarm temperature shall be 190 deg F. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with polyethylene outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short circuit wires at the location of elevated temperature.

2. Control Panel: Suitable for multiple detectors. Provides same system power supply, supervision, and alarm features as specified for the FACP

3. Signals to the FACP: Any type of local system trouble is reported to the FACP as a composite "trouble" signal. Alarms on each detection zone are individually reported to the FACP as separately identified zones.

4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP for each detector zone.

5. Mounting: Linear heat detector shall be mounted to the underside of the escalator housing as shown in the plans using a cable messenger. Stand-off brackets with a rubber grommet shall be installed every 50 feet. Turnbuckles shall be installed on the cable messenger at minimum intervals of 250’.

K. Voice Evacuation System (VES)

1. General Requirements for VES panel:
   a. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL. Panel shall be listed for fire alarm service.
      1) System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), 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. Digital Message Repeater Capable of storing messages
   d. Digital Signal processor for digital audio, tone generation and controls.
   e. Built in microphone for field messaging.
   f. Alphanumeric Display and System Controls Display alarm, supervisory, and component status messages and the programming and control menu.
g. Class A, 70.7 VRMS Audio signals

h. Support distributed amplification for audio circuits.

i. Integral power supply and back up batteries.

2. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated.

a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated

3. Visible Notification Appliances: Strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved on the lens.

a. Rated Light Output: 15/30/75/110 cd, selectable in the field.

b. Mounting: Wall mounted unless otherwise indicated.

c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

d. Flashing shall be in a temporal pattern, synchronized with other units.

e. Mounting Faceplate: Factory finished, red

L. Remote Indicators

1. Indicator (LED or lamp) for flush mounting in ceiling or wall. Normal condition shall be compatible with area smoke detector indicators (i.e. illumination upon alarm, extinguish upon return to normal).

M. Magnetic Door Holders

1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

a. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.

b. Wall-Mounted Units: Flush mounted unless otherwise indicated.

c. Rating: 120-V ac.


N. Addressable Interface Device

1. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

2. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall, to circuit-breaker shunt trip for power shutdown or to solenoid valve for activation of exposure protection system.

O. Wire and Cable
1. Wire shall be rated for the application and the environment it is installed.

2. Wire shall be RHW, #14 AWG minimum, rated for fire alarm service.

3. Cable for communication connection with the tunnel FACP shall be 6 fiber SMFO, suitable for installation in tunnel, damp environment, HDPE insulation, 0.7dB @1310 nm typical attenuation, compatible with Fire Alarm Control Panel.

P. Labels

1. Indicating lights and controls shall be permanently labeled as to their function.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The installation of the system shall meet all requirements of NFPA 70 and NFPA 72.

B. Circuit breakers in the panels feeding the control panel shall be fitted with suitable guard, such that the breaker cannot be turned off, but fixed so the breaker can trip and requiring the removal of a screw to remove the guard. Separate breakers shall be provided for each control panel main power and trouble circuits.

C. Conductors shall be copper and shall be of the type and size specified herein or as required to meet the voltage drop requirements of the circuit.

D. Ground fire-alarm control panel and associated circuits; comply with IEEE 1100 and with Section 26 05 26, Grounding and Bonding for Electrical Systems. Install a ground wire from main service ground to fire-alarm control panel.

E. Junction boxes containing fire alarm circuits shall be painted red.

F. Remote Indicators: Provide in an adjacent area where readily visible for all concealed detectors.

G. Smoke detector spacing shall be in accordance with the listed spacing, the manufacturer's recommendations and the requirements of NFPA 72. Detectors shall not be located within 5 feet of a supply air register nor within 12 inches of a lighting fixture. Duct detectors shall be located to comply with SBC and NFPA 72.

H. Visual Indicators

1. Locate to meet the requirements of ADA and the City of Seattle.

I. Devices

1. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

   a. Smoke dampers in air ducts of designated air-conditioning duct systems.
   
   b. Connection to elevator recall system and components.
   
   c. Connection to Fire suppression systems
d. Connections at valve supervisory switches.
e. Flow or pressure switch of each sprinkler system.
f. Supervisory connections at elevator shunt trip breaker.
g. Supervisory connections for the Paging System to be installed in the future.

2. Relays and other devices to be mounted in auxiliary panels are to be securely fastened to avoid false indications and failures due to shock or vibration.

J. Wiring

1. Within Sub-panels: Shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.

2. Each conductor shall be identified as shown on the installer drawings with wire markers at every splice and terminal point Mark both ends with alphanumeric wire markers.

3. Wiring shall be Class A in accordance with NFPA 72. Control circuits shall be Class B with an end of line resistor on the last device on the circuit

4. Wiring for the fire alarm system shall be kept physically and electrically separate from all other power and signal system wiring.

5. Provide conductors and power supplies of sufficient size to minimize voltage drop consistent with the proper operation of all devices.

K. Auxiliary Controls

1. Destructible link smoke dampers shall not be connected to the fire alarm system. Fan Shutdown Control Circuits, Smoke Removal Control Circuits supervised (subject to NFPA 72 requirements) and may be incorporated into the fire alarm raceway system, except that limited energy circuits shall be routed separately from line voltage circuits as required by the National Electrical Code (NFPA 70).

3.02 CONSTRUCTION

A. System Operation

1. Activation of any single alarm initiating device (smoke detector, water-flow switch, heat detector, etc.) shall cause the following actions and indications:
   a. Initiate a prealarm signal at main control panel (FACP)
   b. Indicate the fire device and/or fire zone on the FACP.
   c. Report prealarm to the Central Control System through the BMS.

2. Activation of a second alarm initiating device, Preaction system alarm, clean agent alarm, sprinkler water flow or elevator heat detector shall cause the following actions and indications:
   a. Initiate a full alarm signal at the main control panel.
   b. Indicate the fire device and/or fire zone in alarm on the FACP.
c. Selectively operate evacuation alarm signaling on the floor of fire detection or as otherwise programmed.

d. Close all fire doors, smoke doors, and ventilator hatches, etc. on or associated with the respective floor of alarm.

e. Signal elevator controllers for primary and alternate floor recall if applicable.

f. Report system status to the Central Control System through the BMS.

3. Activation of any supervisory condition causing device (tamper switch, valve supervision device,) shall initiate a supervisory alarm signal at main control panel, and the BMS.

4. Any system trouble caused by wiring failure including open circuits, grounded circuits and shorted circuits on circuitry required to be supervised in this manner; communications loss, device removal, battery low voltage, power loss, charger failure or failure in any device shall cause the following actions and indications:

a. Initiate a fire alarm system trouble signal at the FACP.

b. Transmit the trouble condition to the BMS.

5. All signal circuits including evacuation circuits, water flow indication circuits, trouble circuits and supervisory indicating circuits shall be silencable by means of a switch on the control panel front. Subsequent alarm receptions shall cause the alarm signals to resound indicating the reception of a new alarm condition. The signals shall also be caused to resound by the re-operation of the signal silence switch allowing evacuation signaling from the silence switch without keyboard commands when an alarm condition exists.

3.03 FIELD QUALITY CONTROL

A. Test Equipment

1. Provide all test equipment, instruments, tools and labor required to conduct the system tests.

2. The installer shall use test instruments that bear valid calibration stamp showing date of calibration and the expiration date of the stamp. Calibration and accuracy of test instruments shall be certified by an independent testing laboratory having standards traceable to the National Institute of Standards and Technology.

a. All alarm and control functions.

b. All trouble and supervisory functions.

c. Transfer to battery power.

B. Acceptance Testing

1. Installer shall be responsible for acceptance testing in accordance with the ATP, demonstrating the functionality of the system and verifying the correct operation of all system components, circuits, and programming.

2. A program matrix shall be prepared, by the installer, referencing each alarm input to every output function affected as a result of an alarm condition on that input.
In the case of outputs programmed using more complex logic functions involving "any", "or", "not", "count", "time", and "timer" statements; the complete output equation shall be referenced in the matrix.

3. A complete listing of all device labels for alphanumeric annunciator displays and logging printers shall be prepared prior to the ATP.

4. The installer’s acceptance inspector shall use the system record drawings, in combination with the documents specified herein, during the testing procedure to verify operation as programmed. In conducting the acceptance test, the acceptance inspector shall request demonstration of any or all input and/or output functions.

5. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:
   a. Open analog loop.
   b. Shorted analog loop.
   c. Grounded analog loop.
   d. Open communication link.
   e. Shorted communication link.
   f. Grounded communication link.
   g. Open zone wiring.
   h. Grounded zone wiring.
   i. Open signal circuit wiring.
   j. Shorted signal circuit wiring.
   k. Grounded signal circuit wiring.
   l. Initiating device removal.
   m. Battery disconnected.
   n. Primary power disconnected.

6. System evacuation alarm signaling shall be demonstrated as follows:
   a. All signals actuate as programmed.
   b. Signal audibility.

7. System indications shall be demonstrated as follows:
   a. Correct message display for each alarm input.
   b. Correct annunciator light for each alarm input.

8. System charging current shall be normal trickle charge for a fully charged battery bank.
9. Demonstrate satisfactory operation to the Seattle Fire Department.

C. Certification

1. Manufacturer's representative shall submit a letter stating he has tested the system and found it acceptable in all respects.

D. Fire Department Acceptance

1. In addition to the proof-testing specified, the installation shall be subject to test by the local Seattle Fire Department.

E. Training

1. The installer shall furnish training to a minimum of four Sound Transit employees as follows:
   
   a. Training in the receipt, handling and acknowledgment of alarms.
   
   b. Training in the system operation including manual control of output functions from the system control panel.
   
   c. Training in the testing of the system including logging of detector sensitivity, walk test of devices and response to common troubles.
   
   d. Training in the programming of the system, including writing program logic modules, entering into the software and uploading and downloading the program to the system.
   
   e. The total training requirement shall be a minimum of 4 hours but shall be sufficient to cover all items specified.

F. Project Closeout

1. System documentation shall be furnished to the Resident Engineer and shall include but not be limited to the following:

   a. System record drawings and wiring details including one set of reproducible masters and Contract Drawings.
   
   b. System operation, installation, maintenance and programming manuals.
   
   c. System menu-driven instructions for the alteration, addition or deletion of zones, modification, addition or deletion of zone messages and the modification, deletion or addition of logic modules as required for system operation.
   
   d. Documentation of system voltage, current and resistance readings taken during the installation, testing and ATP phases of the system installation.
   
   e. Updated ADS plans. See Section 28 31 00

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 31 09 00

GEOTECHNICAL INSTRUMENTATION AND MONITORING OF EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. The majority of the instrumentation for the N140 Contract will be installed as part of the preceding N125 Brooklyn Station excavation support and tunneling contract. For a summary of the instrumentation previously installed, refer to the N125 Instrumentation Installation, Monitoring and Transition Plan.

B. This Section includes specifications for furnishing, installing, maintaining, monitoring and decommissioning instrumentation which monitors earth and structure movements, groundwater drawdowns, and structural loads during Work.

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 12 19, Contract Interface

2. Section 01 45 00, Quality Assurance/Quality Control

3. Section 01 57 15, Temporary Construction Noise and Vibration Control

4. Section 01 71 30, Protection and Maintenance of Property and Work

5. Section 03 05 15, Portland Cement Concrete

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. Washington Administrative Codes (WAC)
   a. WAC 173-160 Minimum Standards for Construction and Maintenance of Wells
   b. WAC 173-162 Rules and Regulations Governing the Regulation and Licensing of Well Contractors and Operators

2. Revised Code of Washington (RCW)
   a. RCW 18.104 Water Well Construction Act


4. American Association of State Highway and Transportation Officials (AASHTO):
5. American Society for Testing of Materials International (ASTM)
   b. ASTM D480 Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), Sch 40 and Sch 80

1.03 DEFINITIONS

A. Instrumentation Well: A well in which pneumatic or electric geotechnical or hydrological instrumentation is permanently or periodically installed to measure or monitor subsurface strength and movement. Instrumentation well includes bore hole extensometers, slope indicators, pneumatic or electric pore pressure transducers, and load cells.

B. Maximum Level: Maximum allowable value for a specific geotechnical instrument.

C. Replacement Level: Value at which utilities are required to be replaced between points of zero settlement.

D. Trigger Level: Intermediate value less than the Maximum Level for a specific geotechnical instrument that serves as a trigger for additional measures to be implemented.

E. Well: Water wells, resources protection wells, instrumentation wells, dewatering wells, and geotechnical soil borings.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Instrumentation Monitoring Plan

C. Corrective Action Plan

D. Well Decommissioning Work Plan: Within 45 days of Notice to Proceed.

E. Manufacturers’ Product Data for all types of instruments to be installed, including calibration certificates.

F. Qualifications of Instrumentation Specialist and surveyor.

G. Copies of Start Cards and approved variances for all Instrument Wells.

H. Logs of borings of Instrumentation Wells, including sample data (depth, SPT N-Values) and Soil Descriptions of each sample.

I. Within five working days after completion of installation of each instrument, submit location data as required by the instrumentation schedule shown on the Contract Drawings.

J. Well Decommissioning Work Plan.
K. Provide post-decommissioning submittals to the Resident Engineer within 10 calendar days after completion of the work. These include, but are not limited to, well abandonment logs, waste characterization analytical test results, waste disposal certificates, and other completed forms and documents required by the Washington State Department of Ecology and other permitting agencies.

L. Final Instrumentation Summary Report.

1.05 QUALITY ASSURANCE

A. Perform all instrumentation activities described in this Section, including procurement, under the direct supervision of an Instrumentation Specialist retained by the Contractor and approved by Sound Transit. The Instrumentation Specialist may be an independent individual or employee of an engineering firm, testing laboratory, or similar organization. The Instrumentation Specialist shall be licensed as a Professional Engineer or Geologist registered in the State of Washington with a minimum of 5 years experience designing, installing, and monitoring instrumentation systems similar to those described in this Section. Demonstrate experience by resume and references.

B. Perform all surveying activities under the direct supervision of a licensed Professional Land Surveyor registered in the State of Washington.

C. Calibration

1. Calibrate all instruments prior to installation.

2. Verify calibration results are within the tolerances for the particular instrument as listed on the manufacturer's standard published data sheet for that instrument. Instruments with calibration results that do not fall within the specified tolerances will be rejected.

3. Recalibrate inclinometers, survey instruments, readout units, and other equipment that is used for monitoring on an on-going basis at the manufacturer's recommended intervals or whenever, in the opinion of Sound Transit or the Contractor, there is reason to suspect that the associated data is being affected by calibration changes or errors.

4. Perform all calibration in accordance with the instrument manufacturer's recommended methods.

5. Ensure calibration equipment and standards are traceable to National Institute of Standards and Technology standards and are themselves in current calibration. Submit evidence of traceability and calibration of standards to the Resident Engineer upon request.

D. Sound Transit may observe instrumentation activities. Sound Transit may also conduct Quality Assurance monitoring of instrumentation. Make the site available and otherwise accommodate these activities.

E. Sound Transit will test instruments for proper function upon completion of installation. Provide assistance to Sound Transit in testing instrumentation. Information will be made available to the Contractor within five days after testing.

F. Complete well decommissioning using a well driller licensed in the State of Washington.
1.06 PROJECT CONDITIONS

A. Availability of Data

1. Monitoring data becomes the property of Sound Transit and are not to be disclosed to third parties or published without written permission of Sound Transit.

2. Submit all monitoring data to the Resident Engineer within 24 hours of being acquired.

3. Data developed by Sound Transit will be available to the Contractor within 24 hours of being acquired.

B. Permits and Coordination

1. Sound Transit will acquire all permits, access agreements and other authorizations necessary to perform the instrumentation work described in this Section on private property, per Section 01 41 26, Permits. Sound Transit will provide copies of all documents to the Contractor at the Preconstruction Meeting.

2. Sound Transit will acquire a Project Construction Permit (PCP) to perform the instrumentation work described in this Section and shown on the Contract Drawings within the public right of way.

3. Coordinate activities affecting utilities with the appropriate utility company.

4. Pre-construction utility surveys: In accordance with Section 01 71 30, Protection and Maintenance of Property and Work.

5. Pre-construction building survey: In accordance with Section 01 71 30, Protection and Maintenance of Property and Work.

C. Coordination of Instrumentation with Other Contracts

1. Instrumentation has been installed at the Brooklyn Station as part of the previous N125 contract. Maintain, monitor, repair, and if damaged replace this instrumentation.

2. Coordinate with the N125 contractor and the Resident Engineer to use the existing Instrumentation Data Management System (IDMS) for monitoring and reporting readings.

3. Coordinate with the N125 contractor and the Resident Engineer to take over responsibilities for maintaining and monitoring instrumentation and the IDMS around the University of Washington Station.

4. Reference Section 01 12 19, Contract Interface, and the Contract Drawings for additional information and requirements.

1.07 INSTRUMENTATION MONITORING PLAN

A. Instrumentation to be installed by N140 Contractor.

1. Schedule and outline of procedures and timing for installation of instrumentation wells for electromagnetic instrumentation.
2. Manufacturer’s descriptive literature, including technical specifications, for proposed instruments.

3. Manufacturer’s literature on protective enclosures.

4. Detailed manufacturer’s literature on installation procedures for each instrument, including cable and tubing locations, and methods for protecting instruments during construction.

5. Materials for grout backfill.

B. Instrument Monitoring

1. Baseline or Initial Readings of Existing Instruments.

2. Routine Monitoring

3. Action Level Monitoring

4. System Maintenance

5. Instrument replacement procedures
   a. If an instrument is repaired, replaced or moved subsequent to installation, record new: instrumentation type, as built location, and calibration sheets. Report to the Resident Engineer the reason the original instrument was altered and the date the new instrument was operational.

C. Reporting of Monitoring Data

1. Description of any changes or alterations to the existing Instrumentation Data Management System (IDMS) necessary for new instrumentation including:
   a. How data is posted to IDMS.
   b. Reports generated in IDMS.
   c. Alarms and notification through IDMS.
   d. How access is controlled to IDMS and by whom.

1.08 CORRECTIVE ACTION PLAN

A. Details of actions to be taken in the case that settlement, lateral movement, or groundwater drawdown exceed the Trigger or Maximum Levels indicated on the Contract Drawings.

B. Provide specific actions for the 54-inch steel riveted/lockbar water main, approximate Stations 1188+00 to 1210+00.

C. Include operational changes to reduce the rate of soil movement and groundwater drawdown.

1.09 WELL DECOMMISSIONING WORK PLAN

A. Submit at least 60 days prior to beginning the decommissioning work. Allow 14 calendar days for the Resident Engineer to review the Plan.
B. At a minimum, include the following in the work plan:

1. Schedule of activities.
2. Methods and procedures of decommissioning.
3. Equipment to be used.
4. Driller’s water well drilling license number and qualifications.
5. Waste management procedures.
6. Name, address, contact phone number for anticipated disposal facility.
7. Health and Safety Plan and requirements. Include air monitoring, action levels, and decontamination procedures, in accordance with requirements of appropriate Specification Sections.
8. Emergency and contingency procedures and measures.
9. Copies of Notice of Intent to Decommission a Well.
10. Variances, if any approved.

1.10 FINAL INSTRUMENTATION SUMMARY REPORT

A. After substantial completion but prior to project close out provide a summary of all instrumentation activities. Include the following:

1. Final measurements of all instruments.
2. List instruments for which monitoring levels exceeded the trigger limit.
3. List instruments for which monitoring levels exceeded the maximum limit.
   a. For these instruments describe actions taken to prevent further movement and any remedial work performed.

PART 2 - PRODUCTS

2.01 GENERAL

A. The only new instrumentation installed by the N140 contractor are the boreholes for the electromagnetic interference monitoring locations.

B. Existing instrumentation installed during previous contracts may require repairs or replacement during the N140 contract. This section includes requirements for materials and installation procedures associated with repairing or replacing these instruments.

C. Verify all instruments and equipment are the manufacturer’s standard products without modifications except those that may be noted below.

D. For vibrating wire instruments, ensure the manufacturer submit test data demonstrating that the sensor has been stable, within the accuracy requirements of this Section, for a period of not less than 5 years under laboratory conditions, when thermal effects have been considered. Instruments for which such stability data cannot be submitted are not to be considered “or equal”.

E. Where model numbers are given in this Section, interpret them to represent models selected on the basis of past factory specifications and project experience demonstrating that the equipment will meet the specified performance objectives. Verify with the selected manufacturer that the designated model, or the updated version, or allowed equal, meets the design performance requirements described in this Section.

F. All instruments, except inclinometers and survey system instruments which cannot be readily automated shall be fully compatible with dataloggers and associated software described in this Section, without loss of accuracy or function.

G. Unless otherwise indicated, only use signal cables for instruments provided by the manufacturer of the associated instrument and suitable for the expected environment. Do not splice cables between the instrument and datalogger unless absolutely necessary.

2.02 MATERIALS

A. Grout mix for all instrumentation installations: Mixture of 94 pounds of portland cement, 25 pounds of bentonite, and 30 gallons of water. (Grout Ration 1:0.3:2.5)

B. Cement: Portland Cement, per Section 03 05 15, Portland Cement Concrete.

C. Concrete: Class 3000 A mix per Section 03 05 15, Portland Cement Concrete.

D. Epoxy Mortar: Two-component, 100 percent solids, 100 percent reactive compound suitable for use on dry or damp surfaces. Use Sikadur 32 Hi-Mod produced by Sika Chemical Corp., or approved equal.

E. Bentonite:
   1. Premium grade Wyoming sodium montmorillonite manufactured in accordance with API RP 13A.
   2. Bentonite pellets: Compressed Wyoming bentonite of pellet size 3/8 inch to ½ inch, Baroid Industrial Drilling Products Company or approved equal.

F. Materials for Well Decommissioning:
   1. Obtain water from an approved, potable water source.
   2. Bentonite.
   3. Use high early strength, Type III Portland cement.

2.03 INCLINOMETERS

A. Inclinometer Probe:
   1. Slope Indicator Co. (Sinco) Model 50302500, Geokon Model 6000 or approved equal.

   2. Measurement Requirements:
      a. Resolution: 0.0001 feet per 2 feet
      b. Accuracy: within 0.025 feet per 100 feet
      c. Range: within 35 degrees from vertical
B. Inclinometer Cable:
1. Slope Indicator Co. Model 50601000, Geokon Model 6000-4 or approved equal.
2. Steel core wire, Neoprene cable jacket, depth marks vulcanized to jacket every foot.
3. Constructed to prevent slippage between jacket and core.
4. Connectors as recommended by manufacturer.
5. Minimum length: 200 feet.

C. Readout unit: Slope Indicator Co. Model 50310900, Geokon Model GK-603 or approved equal.

D. Inclinometer Software:
1. Computer software for uploading casing information to readout device, downloading instrument readings to computer, data reduction, and plotting. Use software that is compatible with the specified probe and read-out device.
2. Software capable of plotting:
   a. Multiple profiles of the same casing on the same plot calculated from the bottom up or the top down.
   b. Real-Time-Displacement at selected depths.

E. Ancillary equipment: provide pulley assemblies compatible with casing and probe, and other accessories for a complete and functional system.

F. Casing
1. Slope Indicator Co. Models 51101100 or 51150210, Geokon 6400 or approved equal.
2. Material: Acrylonitrile/butadiene/styrene (ABS) with internal grooves at 90 degree intervals.
3. Diameter: 2.75-inch Outer Diameter, 2.32-inch Inner Diameter.
4. Spiral / misalignment: no more than 0.033 degree per foot
5. Couplings: as provided by casing manufacturer.
6. Casing cement (if used): As recommended by manufacturer for temperature and humidity conditions at the site.
7. Top and bottom end caps: As provided by casing manufacturer.
8. Ancillary equipment: Pop rivets, rivet gun, joint tape, pipe clamps, and other equipment as recommended by casing manufacturer for a complete and functional system.

G. Tremie Tube
1. Continuous polyethylene or approved equal.

3. Wall thickness sufficient to withstand external hydrostatic pressure and internal grout pressure.

H. Backfill: Grout backfill mix specified herein.

I. Protective Enclosure: As specified herein.

2.04 SURVEY SYSTEM

A. Surface Settlement Points: As shown on the Contract Drawings.

B. Structure Settlement Points: As shown on the Contract Drawings, or use adhesive-backed targets, Leica Models #635-317 (20mm square), #635-318 (40 mm square), or #635-319 (60 mm square).

C. Utility Settlement Points, as shown on the Contract Drawings.

1. Fiberglass bar: Fibergrate Dynaform®, Tencom P626, or approved equal.

2. Epoxy Mortar: Compatible with fiberglass and utility materials, service life minimum 5 years under wet conditions.

D. Wall Survey Points: Adhesive-backed targets, Leica Models #635-317 (20mm square), #635-318 (40 mm square), or #635-319 (60 mm square), or approved equal.

E. Protective Enclosures: As specified herein.

F. System Accuracy Requirements

1. The accuracy requirements established in this Section apply to the final data, including the composite effects of reflectors, readout instruments, measurement methods, temperature, operator variability, and other contributing factors.

2. All accuracies in this Section have an associated confidence level of 90 percent.

3. Survey points used for monitoring ground surface settlement:

   a. Within 0.01 foot vertical
   b. Within 0.01 foot horizontal

4. Reflectors installed on temporary or permanent structures:

   a. Within 0.01 foot vertical
   b. Within 0.01 foot horizontal

5. Optical monitoring lines: 0.01 foot perpendicular to the line.

2.05 STRAIN GAGE SYSTEM

A. Furnish a strain gage system including weldable vibrating wire strain gages, thermistors, signal cables, read-out device, and surface mounted terminal enclosures, as manufactured by Slope Indicator Co., Geokon or approved equal.

B. Provide weldable vibrating wire strain gages with:
1. Maximum strain range of 3,000 microinches per inch.

2. Average sensitivity of one microinch per inch.

3. Temperature range of minus 40 to 150 degrees F.

4. Signal cable with four conductors, rubber insulated and shielded.

5. Service life minimum of 3 years under normal conditions.

6. Thermistors furnished integral to each strain gage.

7. Slope Indicator Co. Model 52602101 with strain gage sensor Model 52623000, or Geokon Model 4000, 4100 or 4150, or approved equal.

C. Provide waterproof signal cables and connectors in sufficient lengths and numbers for operation of the approved strain gages, as recommended by the manufacturer. Each signal cable shall be clearly labeled with a unique strain gage designation.

D. Provide protective conduit for the signal cables.

E. Provide steel protective covers over all strain gages. The protective covers shall be designed and mounted so as not to affect the operation of the gages, as recommended by the strain gage manufacturer.

F. Provide weatherproof enclosures for termination of signal cables with:

1. Hinged doors that provide rapid and convenient access, without unbolting and removing the entire enclosure.

2. Lockable and keyed alike, provide three sets of keys to Sound Transit.

3. Fitted with flanges, brackets, or other equipment appropriate for the associated type of mounting. Mounting equipment shall be welded or otherwise attached to the enclosure and shall not penetrate the protective enclosure via bolt holes or similar opening.

4. Standard fittings for conduit and cable entry.

5. Terminal board for individual cable connections.

6. Manual switch plates with connectors for the read-out device. Each strain gage designation shall be clearly marked at the switch position to which it was connected.

7. Model 57711600, as supplied by Slope Indicator Co., Model 4000-6 as supplied by Geokon for arc weldable strain gages, Model 4100-5 as supplied by Geokon for the 4100 strain gage, or approved equal.

2.06 PIEZOMETERS

A. Use piezometers of the vibrating wire type, Slope Indicator Co. Model 52611030, Geokon Model 4500S or approved equal.

B. Housing: stainless steel.

C. Use piezometers which include integral thermistors for temperature measurement.
D. Measurement requirements:
   1. Resolution: within 0.025 percent of Full Scale
   2. Accuracy: within 0.1 percent of Full Scale
   3. Range: 100 feet head

E. Protective Enclosures: As specified herein, except with at least 12 inches internal diameter.

2.07 MULTI-POINT BOREHOLE EXTENSOMETER

A. Provide three to five position multiple point borehole extensometers to measure subsurface settlement. Use a reference head with an electric sensor with a total system accuracy not less than 0.1 inch.

B. Anchors and Rods:
   1. Three to five mechanically or hydraulically operated anchors set at depths as indicated on the Contract Drawings. Use Slope Indicator Co. Model 51703952, Geokon Model A-5 or approved equal.
   2. Non-corrosive rods individually sheathed in protective tubing.
   3. Rod spacers to space and support rods.
   4. All necessary couplings, caps, fittings, installation tools and accessories.

C. Electrical Reference Head:
   1. Vibrating wire transducers, Slope Indicator Co. Model 52636325, Geokon Model 4450VW or approved equal. Provide thermistors for transducers.
   2. Connect reference head to datalogger devices for remote reading as specified herein.
   3. Capable of manual check on readings using a depth micrometer or similar device.
   4. Provide a minimum range of up to 2 inches of heave and 6 inches of settlement.
   5. Provide direct burial PVC jacketed-type cabling for remote readouts.

2.08 GEOPHONE

A. See Section 01 57 15, Temporary Construction Noise and Vibration Control, for Geophone requirements.

2.09 PORTABLE READOUT UNIT

A. Furnish one portable readout unit capable of reading all vibrating wire instruments described in this Section.

B. Slope Indicator Co. Model 52613500, Geokon Model GK-403 or approved equal.

C. Provide connector cables for all instruments to be read with the readout unit.
2.10 DATALOGGER

A. Capable of reading all vibrating wire instruments and other sensors associated with instruments described in this Section.

B. Slope Indicator Co. Model CR1000 Datalogger, Geokon Model 8002 LC-2/16 or approved equal, for monitoring multiple instruments at Brooklyn Station.

C. Slope indicator Co. Models 52613310 or 52614000, Geokon Models 8002 LC-2 or 8002 LC-2/4, or approved equal, for single or four channel dataloggers, respectively, for borehole instrumentation.

D. Provide one single-channel datalogger for each piezometer installed.

E. Provide dataloggers for extensometer installations as follows:
   1. Do not remove dataloggers until 1 month after cross passage construction has been completed.
   2. All other readings can be taken using a portable readout unit in lieu of using dataloggers.

F. Complete with input, output, signal conditioning, communications, and other hardware for a complete and functional system, including but not limited to:
   1. Multiplexers
   2. Local input/output connection for laptop computer
   3. Telephone modem or wireless connection.

G. Software: Capable of comparing the output of each sensor, in engineering units, against user-selected alarm limits, and electronically relaying hourly logged readings to the Contractor’s and Sound Transit’s offices. The alarm systems shall also have 24 hour connection to two pagers, to be assigned to designated representatives of the Contractor and Sound Transit, respectively.

H. Mount the datalogger in a protective enclosure as specified herein that will accommodate each manufacturer’s enclosures for components of the system.

I. Provide a continuous, adequate power source for the data logger in accordance with the manufacturer’s recommendations.

2.11 INSTRUMENTATION DATA MANAGEMENT SYSTEM

A. Use the Instrument Data Management System (IDMS) established by the N125 Contractor.

B. The IDMS shall be capable of:
   1. Storing and disseminating all monitoring data from vibrating wire instruments and other sensors associated with instruments described in this Section.
   2. Automated processing of the instrumentation data to convert readings into meaningful engineering units.
   3. Checks for action levels for each instrument and alerts the Resident Engineer and Contractor in the event an action level is reached.
4. Displays graphs of instrumentation data.
5. Generates reports of instrumentation data.
6. Access to the information is controlled.
7. Argus system provided by SINCO, or approved equal.

2.12 PROTECTIVE ENCLOSURES

A. Provide protective enclosures with the following features, and as indicated on the Contract Drawings:

1. Bolted lids.
2. Painted or otherwise protected from weather, and waterproof to prevent the ingress of water into the enclosure.
3. With flanges, brackets, or other equipment appropriate for the associated type of mounting. Weld or otherwise attach mounting equipment to the enclosure and do not penetrate the protective enclosure (i.e., no bolt holes).
4. A minimum of 3-inch clearance all around the enclosed instrument, or as indicated on the Contract Drawings, or as required by product manufacturers for specific instruments.
5. Materials: Steel or cast iron.

B. Ensure conduit for signal cable penetrates the wall of the enclosure using standard fittings to provide continuous protection for the cable.

C. Ensure signal cables not enclosed in conduit penetrate the wall of the enclosure through standard weather-proof flexible compression (grommet) fittings.

D. For enclosures subjected to vehicular traffic, mount the enclosure flush with the ground surface, and design for H-20 AASHTO loading.

2.13 IDENTIFICATION TAGS

A. Provide each instrument with a stainless steel indented name tag designating the instrument number, as shown on the Instrumentation Schedule on the Contract Drawings.

B. Indent characters a minimum of 3/8 inch high, indented with the indenter marker press provided by name plate manufacturer.

C. Where possible without affecting instrument function, attach name tags directly to instrument using heavy black (UV-resistant) nylon tie-wrap.

D. For name tags that cannot be attached directly to the associated instrument, mount on the associated structure or enclosure as close as practicable to allow convenient, unambiguous reading. Mount using epoxy or other adhesive as recommended by name tag manufacturer. Use a mounting method that is approved by Sound Transit prior to use.
E. For each strain gage, provide an alpha-numeric identifier, approved by Sound Transit at each strain gage location. The identifier shall be stenciled characters two inches high using paint, and permanently marked near the end of the corresponding strain gage signal cable and at the final switch position to which it is connected.

PART 3 - EXECUTION

3.01 GENERAL

A. Be responsible for safety during all instrument installation and monitoring activities. Conduct all instrumentation activities in accordance with applicable Federal, State, and local regulations and all project-specific health and safety plans. Where conflicting requirements are encountered, the most stringent shall apply.

B. Characterize and dispose of all waste generated by work in accordance with applicable regulations and these Specifications.

C. Allow time for and include all instrumentation installation, monitoring, baseline readings, and associated work in the construction schedule.

D. Install all instrumentation complete and functional to the satisfaction of Sound Transit. Replace unsatisfactory instrumentation or associated equipment at own expense.

E. Be responsible for locating utilities before installing instruments that involve digging and drilling. Damage to utilities, structures, or other facilities shall be the Contractor’s sole responsibility.

F. Provide access to all instrument locations and facilitate occasional monitoring of other instrumentation by Sound Transit by temporarily stopping or interrupting certain portions of the work, as may be required as not to delay the work unnecessarily. Schedule and perform work in a manner so as not to delay monitoring by Sound Transit.

G. Upon direction from Sound Transit, remove and dispose of instruments. Do not remove instruments prior to receiving written direction from Sound Transit. Do not decommission instruments installed in boreholes until all excavation and support is substantially complete within 500 feet, or readings have stabilized.

H. Leave instruments that are no longer accessible in place. Cut signal cables from such instruments flush with the structure or ground surface; remove protective enclosures and at least the upper six inches of casing, and backfill conduits with grout backfill mix as specified herein.

I. Fill holes drilled in concrete structures with epoxy mortar to match surrounding concrete.

J. Remove name tags attached to concrete structures and all associated adhesive.

K. Backfill holes from protective enclosure mountings and similar installations with CDF to prevent future settlement.

L. Prepare and submit the instrumentation borehole and well abandonment Start Cards, as well as a copy to the Washington State Department of Ecology. Submit a copy of approved variances.

M. Notify the Resident Engineer at least 7 Days prior to the start of work.
N. Prepare and submit well abandonment logs to the Resident Engineer.
O. Coordinate activities with other components of these Specifications.

3.02 INSTALLATION SCHEDULE

A. Except for strain gages mounted on bracing members, install all instruments and make operational, with stable baseline readings, a minimum of four weeks prior to the start of shoring, excavating, or other work requiring monitoring.

B. Obtain baseline readings prior to the start of associated construction activities, as specified herein. Notify Sound Transit when instruments are ready for baseline readings.

C. Verify baseline readings agree to within the accuracy of the instrument or as approved by Sound Transit.

D. Do not begin construction activities without written approval from Sound Transit.

E. For strain gages, install on the corresponding bracing member after lifting and placing, and prior to excavating more than three feet below centerline of struts. Take zero-load readings before excavating more than three feet below centerline of struts.

F. Portable readout units may be used for testing instrument function prior to connection with datalogger and at other times as necessary. However, implement fully automated (datalogger) reading function prior to the start of construction of the associated feature, or as specified herein.

G. Provide surveyed location of each instrument within 5 working days after installation has been completed.

3.03 PROTECTION

A. Provide at installation protective enclosures, plates, cable conduit, and other equipment as required to protect the instrumentation system from damage during construction.

B. Be responsible at own expense for repairing or replacing instruments or associated components that are damaged during construction, as directed by Sound Transit.

C. Route all signal cables to the corresponding readout station inside of protective conduit.

3.04 INSTALLATION PROCEDURES

A. General

1. For existing instruments, installation procedures are given below if replacement is required due to damage during construction.

2. Unless otherwise specified, install all instruments in accordance with the manufacturer’s recommendations and requirements. Manufacturer’s recommendations are included as a part of these Specifications by reference, and are applicable, regardless of whether a particular recommendation is explicitly stated in this Section or not.

3. Adhere to manufacturer’s requirements for alignment of instruments.

4. Follow manufacturer’s precautions on handling. Many of these instruments are susceptible to damage if not handled properly.
5. For instruments installed in boreholes, perform the following:
   a. Obtain soil samples at 5-foot vertical intervals in conjunction with the Standard Penetration Test (SPT).
   b. Preserve soil samples in airtight jars or plastic bags and submit to the Resident Engineer. Include the following information on the sample container in permanent ink: instrument designation, date, sample number, sample depth, and sample SPT value.
   c. Provide the following information on boring logs for each instrument installation: instrument designation, date, logger’s name, sample numbers, sample depths, SPT values, and descriptions of soil samples in accordance with the Unified Soil Classification System (USCS).

B. Inclinometers

   1. Install inclinometer casings to the depths of the original instrument.
   2. Install inclinometer such that the bottom of casing is within 1 degree of vertical, referenced to the top of the casing at the ground surface or top of slurry wall.
   3. For cemented casing, join casing using casing cement followed by installation of pipe rivets at 90-degree intervals around casing for each pipe section (total eight rivets). Join other types of casing as recommended by casing manufacturer.
   4. Tape all joints and install bottom cap to prevent grout entry.
   5. Attach tremie tube to outside of casing using wire or tape. Align end of the tube to be even with bottom of casing, allowing filling of borehole from the bottom up. Block bottom of the tremie tube, to force grout through side ports.
   6. Orient inclinometer casing so that the orthogonal grooves are positioned parallel and perpendicular to the expected direction of movement, typically perpendicular to the long axis of the excavation, tunnel, or retaining wall, as approved by the Resident Engineer. Temporarily close top of casing to prevent entry of foreign material.
   7. Fill casing with water and anchor casing as required to prevent it from floating out of the borehole during installation.
   8. Fill the annular void between the drill hole and the inclinometer casing with backfill grout in one continuous stage, pumped through the tremie tube. Collect minimum 3-inch diameter jar sample of grout at time of installation to verify setting time.
   9. Do not install protective cap or otherwise disturb inclinometer for a minimum of 24 hours after installation, or until backfill grout has set, as approved by the Resident Engineer.
   10. Install protective enclosure concentric with inclinometer casing to a depth of at least 3-feet below ground surface. Center inclinometer casing inside the protective enclosure, and fill annulus with grout to 12-inches below top of inclinometer casing. Backfill around outside of casing to ground surface with concrete of CDF to ensure that casing will remain in position.

C. Utility Settlement Points
1. Remove pavement over utility by coring or cutting. Minimize area of pavement removal.

2. Excavate to top of utility using vacuum truck, hand auger, or other suitable method. Do not damage utility.

3. Install temporary casing, trench box, or similar protective equipment as required to provide safe support and access for installation of settlement point.

4. Clean top surface of utility as recommended by epoxy manufacturer to ensure adequate bond with fiberglass bar.

5. Install bar and pipe riser as indicated on Contract Drawings. Maintain centralized alignment throughout installation. Do not allow bar to contact the inside of the riser pipe.

6. Install protective enclosure at pavement surface to accommodate traffic and prevent vandalism or other disturbance of measurement point.

D. Strain Gages

1. Install strain gages in accordance with the manufacturer’s printed installation instructions.

2. Install all strain gages on the corresponding bracing members with steel covers, and stenciled gage identification numbers next to the gages. Mark corresponding identification numbers on each signal cable.

3. Anchor protective conduit at 5-foot maximum intervals.

4. Install terminal enclosures adjacent to each section of instrumented struts, in protected location, and with convenient access for Sound Transit.

5. Connections to datalogger shall be made in accordance with the strain gage manufacturer’s recommendations.

E. Piezometers

1. Support all downhole components during installation to prevent damage.

2. Measure the depth of the sensor by measuring the length of sensor and signal cable in the casing, to the nearest 0.1 foot.

3. Backfill around piezometer and boring with backfill grout mix as specified herein.

4. Provide protective enclosure as specified herein.

F. Multi-Point Borehole Extensometer:

1. Drill borings for the extensometer of a diameter as recommended by the instrument manufacturer, to provide a borehole in which to install the anchors and rods.

2. Bundle and install extensometer anchors in one installation at the depths of the original instrumentation.

3. Install electrical reference head, and hook up to datalogger.

4. Provide protective enclosure as specified herein.
G. Soldier Pile Shoring Monitoring: Install a structure settlement point on the top of every other soldier pile, in addition to other instrumentation indicated on the Contract Drawings.

H. Wall Survey Points: As indicated on the Contract Drawings.

3.05 MAINTENANCE

A. Maintain all instrumentation in accordance with manufacturer’s recommended procedures and schedule, or as directed by Sound Transit, including instrumentation installed during previous contracts.

B. Replace damaged installations, which are the result of the Contractor’s operations immediately, including instrumentation installed during previous contracts.

C. Report all damaged or non-functional instrumentation to the Resident Engineer immediately.

3.06 INSTRUMENT MONITORING

A. General

1. Perform monitoring activities for all instrumentation specified herein. Reference the Contract Drawings and requirements specified herein for monitoring frequency for each instrument.

2. Provide all necessary assistance in the form of labor and equipment to enable Sound Transit to access those instruments, which Sound Transit will occasionally monitor. These may include, but are not limited to, removing obstacles or obstructions and providing access to elevated instruments.

3. When instruments detect sudden changes in measured properties, values that exceed Trigger or Maximum Level values, or other notable conditions, take additional readings as required. Coordinate monitoring activities for extensometers at cross-passages with in-tunnel instrumentation in accordance with Section 31 09 13.50, Tunnel Instrumentation and Monitoring.

B. Baseline Readings:

1. Obtain baseline readings from all instrumentation.

2. Provide baseline readings by conducting three separate and complete sets of readings on each instrument at least one day apart each. Readings will be taken with sufficient accuracy to produce similar results in each of the three readings.

3. Submit electronic copies using files in the latest version of Microsoft Excel and/or specialized software specified herein associated with the instruments described in this Section and paper copies of the data from readings of monitoring instruments and settlement points taken as indicated herein, to Sound Transit within 12 hours after the readings are taken.

C. Action Levels:

1. Action levels are as defined herein, and values for each instrument are indicated on the Contract Drawings or specified herein. Levels indicated are the following, for each type of instrumentation:

   a. Surface settlement points, structure settlement points, soldier pile monitoring points, wall survey points: Total movements.
b. Extensometers and utility settlement points: Vertical movements.
c. Inclinometers: Horizontal movements.
d. Piezometers and observations wells: Groundwater drawdowns.
e. Geophones: Velocity.
f. Strain gages: Strain.

2. When instrumentation data indicates strains, or horizontal or vertical movements in the ground or on structures or existing buildings, buried utilities or surfaces, exceed the action levels, implement the following procedures specified herein.

3. Exceeding Action Levels:
   a. Trigger Level:
      1) Verify measurement and notify the Resident Engineer immediately after obtaining measurements that exceed the Trigger Level for that instrument.
      2) Double the frequency of future monitoring of that instrument and adjacent instruments until movements have stabilized.
      3) Implement procedures in order to limit further movements.
      4) Perform leak tests on utilities as show on the contract drawings. Coordinate testing and leak repairs with Seattle Public Utilities (SPU).
   b. Maximum Level:
      1) Verify measurements and notify the Resident Engineer immediately after obtaining measurements that exceed the Maximum Level for that instrument.
      2) For all values exceeding those indicated, and depending on conditions, Sound Transit may suspend excavation and associated activities at that location, and require the Contractor to submit alternative proposals for minimizing further movements.
      3) If work is suspended, obtain approval from Sound Transit prior to restarting excavation at that location, under approved procedures.
      4) Monitor geotechnical instruments continuously until ground and/or the structure have been stabilized. The Resident Engineer has the discretion to reduce the frequency of monitoring if readings stabilize.

D. Replacement Levels
   1. Replace utilities between points of zero settlement along the utilities if the following movement levels exceed those shown on the contract drawings.
   2. For sewer and storm drains: Replace any sagged sections and match existing slopes.
3. Coordinate work with the appropriate utility companies.

E. Soldier Pile Shoring and Wall Survey Point Monitoring
   1. Conduct optical surveys for vertical and horizontal movements.
   2. Take readings a minimum of twice weekly during mass excavation.
   3. Take readings a minimum of once per week after completion of mass excavation and after wall movements have stabilized. Continue readings on this schedule until directed to modify or cease readings by Resident Engineer.
   4. Action levels: Follow procedures specified herein for other instrumentation if the following levels are exceeded.
      a. Trigger Level: 0.6 inch.
      b. Maximum Level: 1.0 inch.

F. Strain Gage Monitoring
   1. Perform monitoring as shown on the Contract Drawings. Monitor gages once per week during construction activities.
   2. Action levels for bracing members: Follow procedures specified herein for other instrumentation if the following levels are exceeded.
      a. Trigger Level: 500 microstrain.
      b. Maximum Level: 700 microstrain.

3.07 WELL DECOMMISSIONING

A. Decommission Wells in accordance with the regulatory requirements and/or approved variance. Do not decommission wells without approval from the Resident Engineer.

B. Decommission wells per the following schedules, as indicated on the Contract Drawings for each well:
   1. Schedule C: Decommission after construction, but prior to final Substantial Completion.
   2. Schedule D: Decommission well prior to placement of the bottom slab.
   3. Schedule E: Do not decommission well. Well will be monitored and decommissioned as part of a subsequent contract.

C. Contain and containerize all ground water flowing out of the wells during decommissioning. Store ground water in 55-gallon drums or a temporary holding tank.

D. Restore the surface to conditions to match the surrounding ground surface.

3.08 WASTE MANAGEMENT

A. Collect and properly dispose of all waste generated during well abandonment.

B. Handle and dispose of groundwater collected in accordance with Section 31 23 19, Dewatering.
C. Handle and dispose of well material and soil generated from the abandonment procedure as solid waste.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for clearing, grubbing, and disposing of vegetation, including bushes, brush, trees, stumps, logs, roots, rubbish, refuse, trash, and debris within the indicated site limits.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 35 93, Archaeological Finds
2. Section 01 56 39, Temporary Tree and Plant Protection
3. Section 01 57 13, Temporary Erosion and Sediment Control
4. Section 02 41 00, Demolition
5. Section 31 20 00, Earth Moving

PART 2 - PRODUCT

2.01 MATERIALS AND EQUIPMENT

A. Furnish materials, tools, equipment, facilities, and services as required for performing site clearing, grubbing, and other site preparation work.

PART 3 - EXECUTION

3.01 PREPARATION

A. Prior to clearing and grubbing operations, notify the Resident Engineer at least one week in advance of planned activities and make work sites available to Sound Transit’s Archaeologist for observation. Notify the Resident Engineer in the event artifacts are discovered during clearing and grubbing work. Comply with the requirements of Section 01 35 93, Archaeological Finds.

B. Protect survey markers and monuments, existing improvements, and adjacent properties from removal and damage.

C. Protect all trees, lawns, and planted areas that are not in direct conflict with the work shown on the Contract Drawings. Restore all on-surface disturbed areas to a condition satisfactory to the Resident Engineer.

D. Care of Existing Trees and Plants: Protect trees and plants indicated and as specified in Section 01 56 39, Temporary Tree and Plant Protection.
E. Review with the Resident Engineer the location, limits, and methods to be used before clearing work. Perform clearing and grubbing in compliance with all local, state and federal laws and requirements pertaining to clearing and grubbing.

F. Coordinate the work of this Section with the work of Section 02 41 00, Demolition.

G. Perform work in accordance with the requirements of Section 01 57 13, Temporary Erosion and Sediment Control.

3.02 CLEARING AND GRUBBING

A. Clear and grub the site within the limits indicated on the Contract Drawings and remove cleared materials and debris from the site. Unless otherwise indicated, clearing and grubbing includes removal of trees, plants, grass, roots and debris from the existing ground.

B. Use extra care when clearing and grubbing within the critical root zone (CRZ) of trees to remain to avoid unwanted root damage. Perform clearing and grubbing in the CRZ under the supervision of the Resident Engineer and the Project Arborist. When clearing and grubbing in areas that are in the CRZ and are to be paved, coordinate with the Resident Engineer and Project Arborist for the establishment of the subgrade elevation and for root trimming and/or protection measures.

C. Coordinate with salvaging of topsoil as specified in Section 31 20 00, Earth Moving.

D. Tree Salvage:

1. Prior to tree removal, attend an on-site meeting with the Resident Engineer to review requirements for tree salvage for each tree.

2. For tree salvage, de-limb all trees and cut into 14-foot sections.

3. Clearly label each log with the tree tag number in weatherproof ink or paint.

4. Salvage the trees in the following list:

   Tree Salvage

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E. Remove stumps and roots completely in excavation areas, utility trenches and under embankments where the original ground level is within 3.5 feet of subgrade or slope of embankments. In embankment areas, where the original ground level is more than 3.5 feet below the subgrade or slope of embankment, cut off trees, stumps, and brush to within 6 inches of the existing ground.

F. Do not start earthwork operations in areas where clearing and grubbing are not complete. Stumps and large roots may be removed concurrently with excavation.

G. Where the work includes requirements for wood chip mulch, acceptable material from clearing and grubbing activities may be used to produce such mulch.

H. Tree Trimming: Remove tree branches in designated areas of the site according to Section 01 56 39, Temporary Tree and Plant Protection.

I. Clear and restore areas used for the Contractor's convenience. Restore such areas to their original condition, and provide mulching, seeding, and planting as required.

J. Backfill: Backfill excavations resulting from work under this Section in accordance with applicable requirements of Section 31 20 00, Earth Moving.

K. Disposal of Cleared Vegetation, Grubbed Material and Waste:
   1. Dispose of removed materials, waste, trash, and debris in a safe manner in accordance with applicable laws and ordinances.
      a. Do not bury or burn trash and debris on the site.
      b. Remove cleared vegetation, grubbed material and waste from the site at frequent intervals so that its presence will not delay the progress of the Work or cause hazardous conditions for workers and the public.
      c. Removed materials, waste, trash, and debris shall become the property of the Contractor. Locating disposal sites and length of haul is the Contractor's responsibility.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes specifications for earthwork, including: excavation and placement of compacted fill, subgrade and foundation preparation; subsurface extraction of miscellaneous structures and facilities indicated or required to be removed; and finish grading.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 35 93, Archaeological Findings
2. Section 01 45 00, Quality Assurance/Quality Control
3. Section 01 56 39, Temporary Tree and Plant Protection
4. Section 01 57 13, Temporary Erosion and Sediment Control
5. Section 01 57 19, Temporary Environmental Controls
6. Section 01 71 23, Field Engineering
7. Section 01 74 00, Cleaning and Waste Management
8. Section 02 41 00, Demolition
9. Section 03 34 00, Cellular Concrete Fill
10. Section 31 11 00, Clearing and Grubbing
11. Section 31 23 19, Dewatering
12. Section 31 23 33, Trenching and Backfilling
13. Section 31 50 00, Excavation Support and Protection
14. Section 32 11 23, Aggregate Base Courses
15. Section 31 23 23, Geofoam Fill
16. Section 33 01 00, Operation and Maintenance of Utilities
17. Section 32 90 00, Planting

1.02 REFERENCES

A. This Section incorporates by reference the latest revision of the following documents.
   c. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
   d. ASTM D2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
   e. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
   f. ASTM D4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
   g. ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2. Washington Administrative Code (WAC):
   a. WAC 296-155 Part N, Safety Standards for Construction Work, Excavation, Trenching and Shoring

3. Washington State Department of Transportation (WSDOT):
   a. Standard Specifications for Road, Bridge, and Municipal Construction

4. City of Seattle (COS):
   a. Standard Plans for Municipal Construction
   b. Standard Specifications for Road, Bridge, and Municipal Construction

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Material source, and all tests and certifications necessary to approve material, including moisture/density relation test results. If on-site material is proposed for use as any of the materials specified in construction, provide test results certifying suitability of said material. Sampling and tests for on-site material suitability shall be performed at a minimum of every 200 cubic yards of material, and shall also be performed randomly at the request of the Resident Engineer.

1.04 QUALITY ASSURANCE
A. Quality Plan: Conform to Section 01 45 00, Quality Control, covering all earthwork operations and the field quality control to be performed.
B. Quality Control: Provide quality control to ensure compliance with specified requirements.
C. Tests: Engage the services of an approved independent soils testing laboratory to perform tests.

D. Tolerances:
1. Construct finished surfaces to plus or minus 1/2 inch of the elevations indicated.
2. Maintain the moisture content of fill material as it is being placed within 2 percent of the recommended moisture content of the material.

1.05 CLASSIFICATION OF EARTHWORK

A. For specification purposes, earthwork shall be classified as follows:
1. Excavation-Common: All excavation involved in grading and construction of the station structure, parking areas, landscaped areas, walkways, roads, driveways, and connections thereto; and all other excavation classified or indicated as common excavation.
2. Subsurface Extraction: Includes removal of abandoned utilities, tanks, walls, foundations, and other miscellaneous subsurface man-made structures that interfere with new construction and are designated to be removed, and the cleaning of such items if they are indicated to be salvaged. Removal of such obstructions at or above grade is specified in Section 02 41 00, Demolition.
3. Structure Backfill: Structure backfill includes furnishing structural fill material, and placing and compacting structural fill material around structures to the lines and grades indicated. Structural fill material includes borrow excavation and material when required.
4. Fill for Raising Grade: Includes raising of subgrade or grade to indicated elevation with structural fill, including moisture-conditioning and compaction of placed fill material. Structural fill material includes borrow excavation and material when required.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Fill and Backfill Materials – General Requirements
1. Select Material for fill and backfill that has been obtained from onsite excavations and has been approved for use by the Resident Engineer. Selected Material meeting specifications shall be used first before new borrow Material is imported.
2. Excavated Material will be considered suitable for fill applications if it:
   a. Is capable of attaining the compaction specified in Article 3.03I, herein;
   b. Is within 3-percent of optimum moisture content as determined in accordance with ASTM D 1557;
   c. Is free from deleterious material such as organic waste, plastics, clay, rocks, concrete, asphalt, or other debris and rubble having a dimension greater than 6-inches;
d. The combined portion of material retained on a U.S. No.4 sieve shall contain no more than 0.20 percent by weight of organic material.

3. Onsite excavated material meeting the above requirements shall be used for any of the following purposes as determined by the Resident Engineer:
   a. Embankment construction,
   b. In lieu of Mineral Aggregate (Type); shall meet the requirements of COS Standard Specification Section 9-03;
   c. Trench backfill

4. Where conditions require the importing of fill or backfill material, use an inert soil or soil-rock material free of organic matter and meeting or exceeding the minimum requirements specified herein for the location.

5. All material to be used for filling and backfilling requires written approval of the Resident Engineer.

B. Structural Fill
   1. Select from suitable on-site excavated or imported material meeting the requirements of Section 9-03.14, Gravel Borrow, Mineral Aggregate Type 17, of the COS Standard Specifications.
   2. Material containing peat, muck, swampland, buried logs or stumps, or other contamination making the material not fit for embankment base is deemed unsuitable.

C. Non-structural Fill
   1. Select from suitable on-site excavated material as determined by the Resident Engineer; otherwise, the Contractor shall import material conforming to Section 9-03.14(3), Common Borrow of the WSDOT Standard Specifications. Material containing wood, organic waste, coal, charcoal, or any other extraneous or objectionable material is deemed unsuitable.

D. Backfill where not otherwise indicated: Gravel Borrow, Mineral Aggregate Type 17 accordance with COS Standard Specifications Section 9-03.14.

E. Structural backfill: Controlled Density Fill (CDF) in accordance with COS Standard Specification 2-09.3(1)E.

F. Cellular Concrete Backfill where indicated: Section 03 34 00, Cellular Concrete Fill.

G. Geofoam Fill where indicated: Section 31 23 23, Geofoam Fill.

H. Materials for Trenching, Bedding, and Backfilling of utilities in accordance with Section 31 23 33, Trenching and Backfilling.

I. Topsoil: As specified in 32 90 00, Planting.

J. Aggregates for pavement bases: Section 32 11 23, Aggregate Base Courses.

K. Aggregates including but not limited to the following categories are to comply with the City of Seattle Standard Specifications Section 9-03:
a. Roadway Ballast  
b. Crushed Surfacing  
c. Gravel Backfill for Walls  
d. Gravel Backfill for Foundations  
e. Pit Run Sand, Washed Sand  
f. Pea Gravel: Mineral Aggregate Type 9  

2.02 SOURCE QUALITY CONTROL  

A. Verify that fill and backfill materials proposed for use have been tested by an independent soils testing laboratory and have been shown to meet specifications. For materials specified to meet the COS Standard Specifications, comply with COS Standard Specification Section 9-03.15 for test methods. In addition to those specified above, use the following test methods:  

4. Percentage of Wear: ASTM C131 or C535 as applicable.  

B. Where classification of soils is necessary to meet specified requirements, perform laboratory tests in accordance with ASTM D2487.  

PART 3 - EXECUTION  

3.01 EXAMINATION  

A. Staking and Grading  

1. Lay out the work, establish all necessary markers, bench marks, grading stakes, and other stakes as required, in accordance with the requirements specified in Section 01 71 23, Field Engineering.  

B. Existing Utilities  

1. Verify on site the location and depth (elevation) of all existing utilities and services before performing excavation work. Refer to Section 33 01 00, Operation and Maintenance of Utilities, for additional requirements. When excavating within 3 feet of an active utility line, perform excavation by hand or hydro vacuum excavation.  
2. Remove already abandoned utilities, or utilities indicated to be abandoned or removed, encountered in the progress of excavating and plug ends.  
3. Immediately report the discovery of active utility lines which are not indicated in the Contract Documents to the Resident Engineer and utility owners involved. Allow the Resident Engineer and utility owners free access to determine the measures deemed necessary to repair, relocate, or remove the utility.
3.02 PREPARATION
A. Erosion Protection: Refer to Section 01 57 13, Temporary Erosion and Sediment Control.
B. Clear and Grub areas indicated on the Contract Drawings prior to earth moving operations in those areas. Refer to Section 31 11 00, Clearing and Grubbing.
C. Perform demolition in accordance with Section 02 41 00, Demolition, prior to earth moving operations in those areas.
D. Comply with Section 01 56 39, Temporary Tree and Plant Protection.
E. Comply with Section 01 35 93, Archaeological Findings.

3.03 CONSTRUCTION
A. Earthwork General Requirements
   1. Dust Control: Refer to Section 01 57 19, Temporary Environmental Controls.
   2. Construction Traffic: Disperse travel paths of traffic and construction equipment over entire width of compacted surfaces so as to aid in obtaining uniform compaction. Protect exposed soil layers with high moisture content from excessive wheel loads.
   3. On-Site Excavation or Borrow Pits: Do not excavate or remove any material from the project site or right-of-way which is not within the designated excavation, as indicated by the slope and grade lines, without written authorization from the Resident Engineer.
   4. Trenching and backfilling for utilities: Refer to Section 31 23 33, Trenching and Backfilling.
   5. Stockpiling of Fill and Backfill Material:
      a. Excavate and separately stockpile suitable fill and backfill material, segregated by type, during the progress of the excavation work. Save sufficient suitable excavated material, if available, for later filling, backfilling, and embankment construction.
      b. Establish excavated material stockpiles on site only in locations where they will not interfere with the progress of the work. It is the responsibility of the Contractor to establish stockpiling offsite, if necessary.
      c. Stockpiling and reuse of excavated material shall be in accordance with COS Standard Specification Section 2-04.3(1)A.
   6. Disposal of Surplus Material:
      a. Excess earth materials, unsuitable materials, and debris shall become the property of the Contractor. Remove material from the site and disposed of in accordance with Section 01 74 00, Cleaning and Waste Management.
      b. Comply with the COS Standard Specification Section 2-04.3(1)B, Disposal of Surplus Material and Unsuitable Material and its referenced sections.
c. The Contractor is responsible for locating an approved disposal site and haul route.

7. Maintenance of Excavations, Slopes, and Embankments:
   a. Excavate and remove material outside the limits of the excavation that is unstable and constitutes potential slides and material that comes into excavations for any reason including from the driving of piles.
   b. Maintain slopes and embankments until substantial completion and acceptance of the work. Promptly repair slides, slipouts, washouts, settlements, and subsidences that occur for any reason, and refinish the slope or embankment to the indicated lines and grades.
   c. Refer also to Section 31 50 00, Excavation and Support Protection, for requirements.

B. Subsurface Extraction
   1. Remove subsurface facilities and obstructions to the extent indicated and in accordance with Section 02 41 00, Demolition.
   2. When subsurface facilities are encountered during excavation that interfere with new construction, and such facilities are not indicated, notify the Resident Engineer promptly for corrective determination.

C. Dewatering
   1. Dewater excavation as specified in Section 31 23 19, Dewatering.
   2. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding areas.
   3. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
   4. Establish and maintain temporary drainage ditches and other diversions outside excavation to convey water. Do not use trench excavations as temporary drainage ditches.

D. Moisture Control
   1. Initiate stormwater runoff control measures to intercept and convey stormwater away from the site. Initiate dewatering measures to eliminate any standing water.
   2. Where subgrade or layer of soil material must be moisture conditioned before compaction because it is too dry, uniformly apply water to surface.
   3. Remove and replace, or scarify and air dry soil material that is too wet to permit compaction to specified density. Soil material removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing, or pulverizing until moisture content is reduced to a satisfactory value.

E. Excavation
1. General Excavation Requirements:
   a. Perform excavation as indicated and required for concrete footings, foundations, retaining walls, exterior paving, floor slabs, concrete walks, and for site levels and grading, and provide shoring, bracing, underpinning, cribbing, pumping, and planking as required.
   b. Comply with applicable requirements of WAC 296-155 Part N.
   c. Excavate the bottoms of excavations to be level, firm, undisturbed earth, clean and free from loose material, debris, and foreign matter.
   d. Excavate to the lines and grades indicated on the Contract Drawings.
   e. Support and maintain excavations by providing structural support of earth walls as specified in Section 31 50 00, Excavation Support Systems, so that sides are stable and will not move. Excavations may be maintained by sloping cut faces where space permits, if calculations sealed and signed by a civil or structural engineer currently registered in the State of Washington, show that the slopes are safe. Ensure calculations consider all existing conditions, including adjacent traffic, construction loading, and other local effects.
   f. Keep trenching widths to a minimum. Allow for adequate working space for installing forms and as required for safety systems for within the limits of excavations.
   g. Remove unstable bottom material. Remove large stones, debris, and compressible soils from excavation bottoms to a minimum depth of 12 inches.
   h. Except as otherwise indicated, preserve the material below and beyond the lines of excavations. Where an excavation is carried below the indicated grade, backfill with structural fill to the indicated grades. Compact as described in Article 3.03.I, herein.
   i. Place excavated material at a sufficient distance from edge of excavation so as not to cause cave-ins or bank slides, but in no case closer than 3 feet from the edge of excavations.
   j. Payment will not be given for over-excavation caused by the Contractor’s negligence or convenience.

F. Backfilling
1. Backfill for utility trenches as specified in Section 31 23 33, Trenching and Backfilling.
2. Use materials removed from site excavations if such material meets specified requirements.
3. Compacted backfill is required around all substructures. Fill holes, pits, and other voids with structural fill and provide compaction in accordance with Article 3.03.I, herein.
4. Allowable thickness of fill lifts depends on the material type and compaction equipment used. Place backfill in layers not to exceed eight inches of loose material for materials to be compacted by heavy equipment, and not more than
four inches of loose depth for material to be compacted by hand-operated tampers.

5. Place and compact backfill material in such manner that unbalanced horizontal loads will not be applied to a newly-placed structure or portion of structure, utility, or pipeline.

6. Do not backfill around portions of cast-in place concrete vaults, manholes or catchbasins requiring backfill on only one side or on less than all sides, until the concrete has reached the specified 28-day strength.

G. Subgrade for Surfacing

1. Comply with COS Standard Specification Section 2-09.3 for preparation of subgrade for roadbed surfacing including provisions for subgrade stabilization when the subgrade does not meet required density and subgrade maintenance and protection.

H. Finish Grading

1. Finish grade all areas to elevations and grades indicated within the specified tolerance.

2. In landscape areas rough grade to the depth required below finished grade to allow placement of specified thicknesses of topsoil and mulch indicated in the Contract Drawings.

I. Compaction

1. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content.

2. Compaction Density: Compact each layer of embankment, fill, and backfill material to not less than the indicated or specified compaction. Required compactions are defined as Class I and Class II, as follows:

   a. Class I Compaction: 90 percent relative compaction as determined by ASTM D1557.

   b. Class II Compaction: 95 percent relative compaction as determined by ASTM D1557.

3. Required Compactions:

   a. Embankment or Fill where the Surface will be Bearing Foundation: Class II for full depth. Where embankment construction exceeds 5 feet in depth, provide minimum Class I compaction below the top 2.5 feet.

   b. Backfill around Structures: Class II for full depth.

   c. Fill Below Pavements: Class II for full depth.

   d. Cut-and-Cover Backfill: Class I to 36 inches above utility; Class II for balance, with a minimum of Class II for top 12 inches.

   e. Non-Structural Fill Below Planting: 85 percent relative compaction as determined by ASTM 1557.
4. Original Ground or Cut Subgrade:
   a. Pavement Subgrade: Provide Class II compaction to a depth of 6-inches for full width of pavement plus 1 foot beyond the pavement edge.
   b. Embankment Subgrade: Provide Class II compaction to a depth of 6-inches of undisturbed original ground upon which embankments are to be constructed.
   c. Where not otherwise indicated or specified and where structures are not involved, provide Class I compaction to minimize settlement.

3.04 FIELD QUALITY CONTROL

A. In-Place Density and Water Content Tests: Test soils to verify compliance with specified requirements in accordance with ASTM D6938. Conduct test frequently enough to be in accordance with the Contractor's Quality Plan, but not less than the following:

1. Perform an initial test whenever material changes or source changes then follow minimum frequency below.

2. Expansive Horizontal Areas: One test per 100 cubic yards of each material type, or fraction thereof, of fill or backfill placed.

3. Confined Areas and Embankments: One test per every second lift of fill, backfill, or embankment placed.

END OF SECTION
1.01 SUMMARY

A. This Section includes specifications for designing, furnishing, installing, maintaining, operating, and removing temporary dewatering systems and controls as required to control water levels and hydrostatic pressures during demolition and excavation; treatment and disposing of pumped water; constructing, maintaining, observing and, except where indicated or required to remain in place, removing equipment and instrumentation when no longer needed.

B. Dewatering includes intercepting seepage within the bottoms of excavations; increasing the stability of excavations; preventing loss of material from bottoms of excavations; disposing of pumped water; monitoring of water quality; and the proper treatment and disposal of contaminated water.

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 41 26, Permits
2. Section 01 57 24, Temporary Site Water Discharge
3. Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork.
4. Section 31 50 00, Excavation Support and Protection.
5. Section 31 66 17, Slurry Diaphragm Wall Cleaning and Repairing.

1.02 SYSTEM DESCRIPTION

A. Design Guidelines

1. Be responsible for the design and adequacy of the methods and systems to accomplish the following:

a. Within plan limits of excavation, lower the groundwater level to below bottom level of excavation throughout construction.

b. Develop a substantially dry and stable subgrade for prosecution of construction operations.

c. Prevent damage to adjacent buildings, structures, utilities, and other work that may result from settlement or other groundwater-related effects.

d. Ensure dewatering design has been reviewed and approved by the impacted utility authorities before start of dewatering work.
e. Comply with requirements of Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork, and instrumentation installations as shown on the Contract Drawings.

2. Methods of dewatering may include sump pumps, single or multiple stage well point systems, ejector type systems, deep wells, and combinations thereof.

3. Methods for creating groundwater cutoff barrier system may include use of secant piles, slurry walls, and combinations thereof, per Section 31 50 00, Excavation Support and Protection, and Section 31 66 17, Slurry Diaphragm Wall Cleaning and Repairing.

4. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Prior to installation of dewatering system, submit working drawings and design data, indicating the following:
   1. The proposed type of dewatering system.
   2. Arrangement, location, and depths of system components.
   3. Types and sizes of filters.
   4. Design calculations demonstrating adequacy of the proposed systems and equipment.
   5. Methods of disposal of pumped water.

C. Submit qualifications of dewatering system designer and operator.

D. Submit copies of the special permits required for performing the work of this Section.

E. Submit records as specified herein.

1.04 QUALITY ASSURANCE

A. Employ a professional civil engineer or certified geologist, registered in the State of Washington and specialized in hydrogeology or geotechnical engineering, to design and direct operation of dewatering system.

B. Provide water quality and quantity monitoring and maintain records as required by the applicable permits.

C. Conduct groundwater discharge, conveyance and transmission to off-site locations in a manner that meets with the approval of the governmental authorities having jurisdiction, and in accordance with Section 01 57 24, Temporary Site Water Discharge.

1.05 PROJECT CONDITIONS

A. Permits
1. Obtain all special permits and licensing for dewatering and disposal of pumped water as required to construct and complete the Work. Coordinate with requirements of Section 01 41 26, Permits and 01 57 24, Temporary Site Water Discharge.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Furnish all materials, tools, equipment, facilities, and services as required for providing the necessary dewatering work and facilities. Make available equipment, machinery and piping, including standby power and pumps in good working order and of adequate capacity to continue dewatering operations in an emergency.

B. Provide piezometers for monitoring groundwater levels and other instruments and measuring devices as required in Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Dewatering System

1. Perform dewatering in accordance with working drawings and design data. Keep the Resident Engineer advised of changes made to accommodate field conditions and, on completion of the dewatering system installation, revise and resubmit working drawings as necessary to indicate the installed configuration.

2. Dispose of pumped material from excavations, and drainage from areas used or occupied for construction and other purposes. Construct pipelines, including underground portions in streets, as are necessary.

3. Arrange discharge line to facilitate taking samples by a regulatory authority.

4. Organize dewatering operations to maintain the groundwater level within excavations as required for prosecution of the work, and to provide a stable, dry subgrade for the prosecution of construction operations.

5. Meet quantity and quality discharge permit requirements as specified under Section 01 57 24, Temporary Site Water Discharge, for pumped water before discharging to approved points of connection to the combined sewer.

B. Groundwater Cutoff Barrier System

1. A minimum of two piezometers shall be used to monitor groundwater pressure outside of groundwater cutoff barrier.

2. Achievement of satisfactory groundwater cutoff barrier shall be based, as a minimum, on submitted readings from piezometers located within and outside of limits of foundation excavation.

3. Groundwater level or piezometer readings will be taken as specified in Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork, while foundation construction is underway until foundation concrete is placed.
4. Properly plug holes drilled in concrete slab for probing or monitoring groundwater.

3.02 MAINTENANCE
A. Dewatering System
   1. Maintain dewatering systems in accordance with working drawing and design data.
   2. Immediately replace materials, equipment and facilities that are damaged or cease to operate properly. Notify the Resident Engineer of replacements made to the dewatering system.

3.03 FIELD QUALITY CONTROL
A. Records
   1. Observe and record the average flow rate and time of operation of each pump used in the dewatering system. Where necessary, provide appropriate devices, such as flow meters, for observing the flow rates. Submit flow-rate data during the period that the dewatering system is in operation.
   2. Observe and record the elevation of the groundwater during the period that the dewatering system is in operation. Submit observation records to the Resident Engineer within 24 hours of reading, on a regular basis.
   3. During initial period of the dewatering, make required observations on a daily basis. If, after a period, dewatering operations have stabilized, reduce observations to longer intervals approved by Resident Engineer.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for excavating, trenching, and backfilling for utilities and related structures, as indicated, including underground piping for water supply, sanitary sewerage, storm sewerage, underground electrical conduits and duct banks, and utility boxes, and vaults.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 71 23, Field Engineering
2. Section 31 20 00, Earth Moving
3. Section 31 23 19, Dewatering
4. Section 31 50 00, Excavation Support Systems
5. Section 33 01 00, Operation and Maintenance of Utilities

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. City of Seattle (COS):
   a. Standard Specifications for Road, Bridge, and Municipal Construction
   b. Standard Plans for Municipal Construction

2. Seattle City Light Material Standards

3. Seattle Department of Transportation (SDOT):
   a. SDOT Director’s Rule 5-2009, Street and Sidewalk Pavement Opening and Restoration.

   a. WAC 296-155 Part N: Safety Standards for Construction Work, Excavation, Trenching and Shoring

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.
B. Provide list of source location and all tests and certifications necessary to approve material, including moisture/density relation test results. If on-site material is proposed for use as any of the materials specified in construction, provide test results certifying suitability of said material.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Bedding and Backfilling Materials:
   1. Mineral Aggregate Type (No.): Type as indicated in accordance with COS Standard Specification Section 9-03 to include:
      a. Type 6 - Washed Sand, Sections 9-03.1(2)C and 9-03.16.
      b. Type 7 - Building Sand, Sections 9-03.1(2)C and 9-03.16.
      c. Type 9 - 3/8" Washed Gravel, Sections 9-03.12(3) and 9-03.16.
      d. Type 17 - Bank Run Gravel, Sections 9-03.12(2), 9-03.14, and 9-03.16.
      e. Type 22 - 3/4" Crushed Gravel, Sections 9-03.11, 9-03.12(3), and 9-03.16.
   2. Controlled Density Fill (CDF): in accordance with the COS Standard Specifications Section 2-10.2(3)A, or a similar material approved by the Resident Engineer.
   3. Fluidized Thermal Backfill (FTB): in accordance with Seattle City Light material Design Standard 7150.00.
   4. Trench Backfill Selected Material: Selected Material is material obtained from onsite excavations on the Project Site that are designated by the Resident Engineer to be suitable for selected fill applications. Selected Material shall be used first before new borrow Material is imported. Selected Material shall be in accordance with COS Standard Specification Section 2-10.2(1).

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Staking and Grades:
   1. Refer to Section 01 71 23, Field Engineering, for requirements.

B. Existing Utilities:
   1. Prior to digging, see Section 33 01 00, Operation and Maintenance of Utilities, for additional requirements.

C. Protection of Persons and Property:
1. Erect and maintain temporary bracing, shoring, lights, barricades, signs, and other measures as necessary to protect the public, workers, and adjoining improvements from damage during trenching work in accordance with applicable codes and regulations.

2. Protect utilities, pavements, and facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by the trenching operations.

3. Protect open trenches outside of secured fence areas with steel plates with non-slip surfaces or water filled barriers during non-working hours. Provide barriers to block pedestrians or vehicles from entering the work area and approaching trenches during working hours.

D. Dewatering

1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

2. Where water is encountered in the trench, dewater as specified in Section 31 23 19, Dewatering.

3. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

4. Establish and maintain temporary drainage ditches and other diversions outside excavation to convey water. Do not use trench excavations as temporary drainage ditches.

E. Trenching and Excavating:

1. Perform work per the requirements of WAC 296-155, Part N, Excavation, Trenching and Shoring, and Section 31 50 00, Excavation Support Systems.

2. Do not undermine or disturb sidewalks, pavements, appurtenant structures, adjacent improvements or underground installations adjacent to and beyond the trench.

3. Excavate to the depth, line, and grade indicated on the Contract Drawings or as referenced in a Standard Plan.

4. Excavate using open cut methods.

5. The maximum trench width in the City Right of Way shall not exceed the neat line trench width indicated on the Contract Drawings or in a referenced COS Standard Plan.

6. Outside the Right of Way and in unimproved areas, trench width above the top of pipe may at the Contractor’s option exceed the neat line trench width indicated or referenced in a COS standard plan, by sloping or benching. All requirements for excavating, handling and disposing of excavated material, and placing and compacting additional suitable backfill, outside of the neat line trench limits shall be at the sole expense of the Contractor.

7. Stockpiling and Reuse of Excavated Material: In accordance with COS Standard Specification Section 2-04.3(1)A.

9. Notify the Resident Engineer if over-excavation is required and/or material in trench bottom is determined unsuitable.

10. Remove unexpected objects such as stumps, logs, railroad ties, buried pavement, etc. encountered in the trench excavation. Notify the Resident Engineer if removal of unexpected objects requires an increase in trench size or if the object(s) cannot be removed by the equipment or excavation method at hand.

11. Remove trench protective systems in such a manner as to not disturb bedding or backfill. Where bedding or backfill is disturbed, reconsolidate the material as specified.

12. Ensure excavations for structures conform to the applicable requirements of Section 31 20 00, Earth Moving.

F. Bedding:

1. For Water Mains:
   a. Water main distribution pipe bedding material shall be Mineral Aggregate Type 6 or 7. Transmission pipe bedding shall be Mineral Aggregate Type 9. Dimensions for bedding for water mains shall be as shown on COS Standard Plan No. 350 Type B. Pipe bedding shall be placed in accordance with COS Standard Specification Section 7-10.3(9).

   b. Provide uniform support along the entire pipe barrel, without load concentration at joint collars or bells. Provide over-excavation for the pipe bells such that pipe barrels and bells along the pipe are uniformly supported full length.

   c. Do not use blocking to adjust pipe to grade. Take special care to provide adequate bedding support at wye or tee connections and adjacent manholes or other structures to avoid bending or shearing stresses at these critical points.

2. For Storm and Sewer Piping:
   a. Pipe Bedding for storm drains and sanitary sewers shall be in accordance with the COS Standard Specifications Section 7-17.3(1)B and in accordance with COS Standard Plan 284 and 285.

   b. Unless otherwise specified in the Contract, bedding for rigid and flexible pipe shall be COS Class B except bedding for ductile iron pipe shall be Class D.

   c. Bedding material for flexible pipe and vitrified clay pipe shall be COS Mineral Aggregate Type 22.

   d. Bedding material for concrete pipe shall be COS Mineral Aggregate Type 9.

3. Bed duct banks on 2 inches of compacted washed sand, Mineral Aggregate Type 6, as indicated.

G. Backfilling: Backfill with Selected Material deemed suitable by the Resident Engineer in accordance with Article 2.01A(4). Otherwise use Borrow material meeting the requirements of COS Mineral Aggregate Type 17 unless otherwise indicated. Take all necessary precautions to protect the pipe, duct bank or vault from any damage or shifting.

1. Pipe and duct bank Backfilling: Backfill evenly from both sides of the trench to a uniform depth of 1 foot above ductile iron pipe before starting compaction, and to a uniform depth of 2 feet above concrete pipe, concrete duct banks, PVC, and other flexible pipes before starting compaction.

2. Electrical Vault backfill in accordance with Seattle City Light Construction Guideline U2-15.1.

3. CDF backfill shall be in accordance with COS Standard Specification Section 2-10.3(7).

H. Compaction: Refer to Section 31 20 00, Earth Moving. The requirement for compaction is Class II Compaction in improved areas such as parking lots or sidewalks. The compaction requirement in unimproved areas or landscaped areas is Class I Compaction.

I. Restoration:

1. Comply with surface restoration requirements as indicated in the Contract Drawings, Specifications or as referenced in a COS Standard Plan.

2. Within City of Seattle Right-Of-Way, comply with City of Seattle's Director's Rule 5-2009 for Street and Sidewalk Pavement Opening and Restoration.

3.02 FIELD QUALITY CONTROL:

A. Refer to Section 31 20 00, Earth Moving, for requirements.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 31 50 00
EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes specifications for designing, furnishing, installing, monitoring, leaving in place, and removing excavation support systems. Locations and extent of these systems are shown on the Contract Drawings.

B. This Section applies to both Sound Transit-designed excavation support systems (Contract Drawings) and Contractor-designed excavation support systems (Working Drawings). Design requirements that apply only to Contractor-designed excavation support systems are noted accordingly.

C. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 03 05 15, Portland Cement Concrete
2. Section 05 12 00 Structural Steel Framing
3. Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork.
4. Section 31 20 00, Earth Moving.
5. Section 31 23 19, Dewatering.
6. Section 31 51 00, Anchor Tiebacks

1.02 REFERENCES

A. This Section incorporates by reference the latest revision of the following documents.


a. ASTM A36 Standard Specification for Carbon Structural Steel
c. ASTM A328 Specification for Steel Sheet Piling
d. ASTM A500 Standard Specifications for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
e. ASTM A572 Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
1.03 DEFINITIONS

A. Anchor Tieback: A horizontal shoring element supporting soldier piles or wales and supported by embedment into and friction against grade. Anchor tiebacks carry axial tension and are typically steel rod or steel wire strand.

B. Design Load: The calculated load carried by a shoring element.

C. Drainage Mat: A manufactured material available in sheets or rolls used behind lagging to prevent buildup of hydrostatic pressure.

D. Existing Construction: Adjacent structures, facilities, equipment, conveyances, and utilities present at the beginning of excavation.

E. Lagging: A vertical shoring element restraining the horizontal movement of a cut soil face and supported by soldier piles or wales. Lagging is typically timber, precast concrete, or shotcrete.

F. Parcel: An area of ground as indicated, including all existing construction upon or connected to it.

G. Raker: A sloping strut, typically supported on grade.

H. Restore: To return to pre-excavation condition by repair or replacement of portions damaged, altered, or removed by excavation activities.

I. Sheet: A vertical shoring element restraining the horizontal movement of a cut soil face and supported by soldier piles or wales. Sheets are typically flat steel plates and do not provide water cutoff.

J. Sheet Pile: A vertical shoring element restraining the horizontal movement of a cut soil face and supported by wales. Sheet piles are typically interlocking profiled steel plate shapes and provide water cutoff.

K. Shore: A horizontal, inclined, or vertical shoring element positioned against or beneath a structure, part of a structure, or utility to restrain movement.

L. Shoring: An excavation support system designed and installed to protect the public and property from potential impact due to excavation activities by limiting the horizontal and vertical movement of soil and adjacent construction. Shoring may be temporary or permanent.

M. Soldier Pile: A vertical shoring element supporting lagging and supported by embedment into grade and tieback anchors, wales, struts, or rakers. Soldier piles are typically rolled steel W-, S- or H-shapes.

N. Strut: A horizontal shoring element keeping two other elements a fixed distance apart, usually soldier piles or wales. Struts carry axial compression and are typically rolled steel pipe, tube or W-, S-, or H-shapes.

O. Tangent Pile: A vertical shoring element restraining the horizontal movement of a cut soil face and supported by embedment into grade and tieback anchors, wales, struts, or rakers. Tangent piles are typically drilled concrete piles set with no space between adjacent piles and reinforced with deformed bars or rolled steel W-, S-, or H-shapes.
P. Tremie: A pipe used to place concrete under water or slurry, displacing the water or slurry during placement.

Q. Tremie Concrete: Concrete placed under water or slurry using a tremie.

R. Underpinning: A vertical shoring element supporting the vertical load of a structure, part of a structure, or utility, supported by embedment into grade.

S. Wale: A horizontal shoring element supporting lagging, sheets, sheet piling, or soldier piles, and supported by anchor tiebacks or struts.

T. Working Drawings: For contractor-designed systems, drawings describing the excavation support system.

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures.

B. Driller's Qualifications.

C. Structural Engineer’s Qualifications: For Contractor-designed excavation support systems.

D. Surveyor’s Qualifications.

E. Welder Certifications: Submit certification that all welders are qualified according to the Washington Association of Building Officials (WABO).

F. Construction Work Plan: Submit a written program. Include descriptions of the following:
   1. Installation procedures
   2. Drilling equipment
   3. Excavation sequence and schedule
   4. Shaft excavation methods, including drilling methods, methods for cleanout of shafts, and disposal plan for excavated material and drilling slurry (if applicable).
   5. Methods to be used to ensure shaft stability, such as temporary casing or slurry.
   6. Interface details for existing construction
   7. Protection measures for existing construction
   8. Instrumentation and monitoring procedures
   9. Removal procedures and sequence
   10. Contingency plans for excessive shoring movements as discussed under Excavation Support System Performance Criteria in Part 1, herein.
   11. Field quality control measures

G. Working Drawings: For excavation support system designed by the Contractor, submit Working Drawings signed and sealed by a structural engineer. Include the following:
   1. Element sizes and locations
2. Element assembly and connection details
3. Interface details for existing construction
4. Interface details for permanent elements

H. Calculations.

I. Structural Steel Shop Drawings: Submit in accordance with 05 12 00, Structural Steel Framing.

J. Soldier Pile Logs: Include for each pile:
1. Pile number, location, size, and location of splices, if present.
2. Date and time of start and completion of pile shaft excavation
3. Elevation of water table during excavation.
4. Soil conditions encountered during drilling.
5. Pre-bored hole diameter, and any variations in diameter with depth.
6. Concrete mix data including design mix number, volume placed, and method of placement.
7. Date and time of installation of concrete encasement.
8. Pile plumbness.
9. Final top and bottom elevations of pile and concrete encasement.
10. Final horizontal location of pile axis, and variation from design location.
11. Other documentation as may be dictated by construction conditions including problems encountered, and delays.

K. Mix Designs: Submit mix designs for all concretes and grouts.

L. Monitoring Program Readings and Results.

1.05 QUALITY ASSURANCE

A. Driller: Select drillers having a minimum of 5 years of experience in preboring holes for soldier piles or work of similar character.

B. Structural Engineer: For contractor-designed excavation support systems, select a licensed civil or structural engineer currently registered in the State of Washington, with a minimum of 5 years of experience in the design and construction of excavation support systems.

C. Professional Land Surveyor: Select a licensed professional land surveyor currently registered in the State of Washington, with a minimum of 5 years of experience in work of a similar character.

1.06 EXCAVATION SUPPORT DESIGN REQUIREMENTS

A. Excavation support systems designed by the Contractor shall meet the following criteria:
3. Support earth pressures as noted on the Contract Drawings, including surcharge loads due to existing construction, equipment, traffic, and construction activities.
4. Driving of soldier piles or sheet piles with vibratory or impact hammers is not allowed.
5. Allow the required free excavated space for workers and groundwater control systems.
6. Conform to excavation and backfill sequences as indicated in the Construction Work Plan.
7. Maximum lateral deflection of any system within 40 feet of City right-of-way is limited to 1 inch.
8. Compatible with conditions described in the Geotechnical Conditions Summary (Appendix A).

1.07 CONTINGENCY REQUIREMENTS

A. Contingency Plan: Have materials and equipment readily available to implement mitigating measures to arrest potential shoring wall movement. Mitigating measures shall be approved by the Resident Engineer.

B. If the 1 inch deflection criteria is exceeded:
   1. Notify the Resident Engineer immediately.
   2. Increase frequency of readings and furnish and install additional instrumentation and monitoring points as determined by the Resident Engineer.
   3. Implement mitigating measures if directed by the Resident Engineer and be prepared to terminate construction activities in the area.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Materials for excavation support systems may be new or used, provided they are sound and free from strength-impairing defects.

B. Concrete: Refer to Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, Section 03 30 00, Cast-In-Place Concrete, and Section 03 05 15, Portland Cement Concrete, for requirements.

C. Metals: For all metal materials other than steel sheet piling refer to Section 05 12 00 Structural Steel Framing. For steel sheet piling use ASTM A328, continuous interlocking type.

D. Tiebacks: Refer to Section 31 51 00, Anchor Tiebacks.

E. Timber:
1. Grade: As specified on the Contract Drawings or approved Working Drawings.

2. Lagging: Lagging shall be rough-sawn. Lagging need not be new, but shall be in serviceable condition.

3. Preservative Treatment: Pressure treat wood members left permanently in place with preservative material in accordance with AWPA U1, Use Category 4A, Commodity Specification A.

F. Do not use combustible waste or similar material for packing or soil retention in excavations.

PART 3 - EXECUTION

3.01 GENERAL

A. Construct excavation support systems in accordance with Contract Drawings or approved Working Drawings and in a manner that will ensure that supported faces will be stabilized.

3.02 FIELD QUALITY CONTROL

A. Monitoring Program: Monitor the shoring at the locations depicted on the Contract Drawings. Monitor in accordance with Section 31 09 00, Geotechnical Instrumentation and Monitoring of Earthwork.

B. Excavation Support System Installation: Retain the services of a geotechnical engineer to observe the installation.

C. Concrete and Grout Testing: Test concretes and grouts in accordance with Section 03 05 15, Portland Cement Concrete.

D. Utility Locations:

1. Utilities in close proximity to soldier piles shall have their locations and depths verified by potholing prior to the start of soldier pile drilling. Refer to the shoring plan for the minimum utilities that need to be potholed, although the Contractor shall pothole any utilities that appear to be in potential conflict with the shoring. Representatives of SDOT and the utility owner will need to be present at the time of potholing, so notify them at least 10 days prior to potholing.

2. Proceed with caution in areas of utility facilities and structures. Expose existing utilities by hand-excavation or by other method acceptable to the utility owner.

3. If existing utility facilities and structures interfere with proposed method of excavation support, modify or relocate such facilities in accordance with the utility owner's recommendations or modify the excavation support systems.

3.03 SOLDIER PILES

A. SEQUENCING AND SCHEDULING

1. Sequence pile installation such that no pile is excavated within a clear distance of 12 feet from concrete encasement less than 12 hours old.

2. Schedule work so that encasement is placed within twelve hours after excavation of pile.
3. Place soldier pile and concrete encasement immediately after excavation bottom is inspected and accepted.

B. EXCAVATION FOR SOLDIER PILES

1. Drilling: Observe the drilling rate and resistance as the boring of each hole is advanced. Record the relative drilling rate.

2. Temporary Casing
   a. Pre-bored holes may require casing through soil to prevent collapse of overburden and control seepage water. Prior to start of drilling, review provided site subsurface data to determine whether casing will be required. The cost of any casing shall be incidental to the shoring system.
   b. Install temporary casing if required, sufficient to withstand handling stresses, concrete pressure, and surrounding earth and water pressures.
   c. Leave the casing in place through the cleaning and inspection operations of the pre-bored holes. Withdraw casing as the concrete is placed.
   d. Begin extraction of casing only after sufficient concrete has been placed in the shaft to achieve a minimum height differential between the bottom of the casing and the top of concrete of 5 feet. Maintain the differential until the concrete achieves finish elevation.

3. Groundwater Control
   a. In the event that groundwater is encountered during excavation operations, pumping of water from the pile excavation will be permitted during construction, provided that the groundwater does not flow into the excavation rapidly enough to carry particles of soil or result in caving of excavation walls, bottom heaving, or ground settlement.

4. Cleaning and Inspecting Pre-bored Holes
   a. After the holes have been bored to the proper depth, remove loose earth or debris, including water, from the bottom and sides of the hole. Leave bottom surfaces flat and level.

5. Do not allow vibration or excessive wheel loads within the immediate vicinity of any pile. Maintain drill hole excavation stability at all times.

C. INSTALLATION OF SOLDIER PILES

1. Place the steel soldier piles and maintain in the center of the pre-bored hole using centering devices. Align the flange of the pile parallel to the future excavation line.

2. Cutting Off Steel Soldier Piles
   a. For pile installation where a longer pile than required was furnished, cut off the pile to the length required.
   b. Make the cut at the location necessary to maintain the tieback openings at the levels shown on the Contract Drawings or approved Working Drawings.
c. Make all cuts perpendicular to the axis of the pile.

d. Remove cut off sections of steel soldier piles from the site and suitably dispose of.

3. Rebuilding or Extending Steel Soldier Piles

a. Extend the soldier pile installations where the depth of the pre-bored holes must be extended beyond the depth shown on the Contract Drawings or approved Working Drawings to obtain a non-yielding foundation for the pile, and where the length of the furnished pile is inadequate for the deepened hole.

b. Provide the length of extension necessary to extend the soldier pile to the bottom of the pre-bored hole, while maintaining the tieback openings at the levels shown on the Contract Drawings or approved Working Drawings.

c. Provide extensions of the same section size and weight as the soldier pile to which it is spliced.

d. Submit splicing details to the Resident Engineer.

D. PLACEMENT OF CONCRETE ENCASEMENT

1. Place concrete encasement in accordance with Section 03 30 00, Cast-In-Place Concrete, and the following requirements:

a. Place concrete in dry excavations whenever practicable. Use all practicable means to obtain a dry excavation before and during concreting.

b. Place concrete for dry excavations by free fall methods. Place concrete equally around the steel soldier pile. Place concrete in each pile continuously to the top elevation.

c. If water accumulates in the pre-bored holes after cleaning and inspection prior to concrete encasement remove water by approved methods, or place the concrete below the accumulated water using tremie methods

1) When the groundwater infiltration rate is greater than 1/4-inch vertical rise in hole per minute, consider soldier pile excavations "wet" and place concrete using the tremie method.

2) Except when concreting by the tremie method, do not allow the total height of water in the bottom of the excavation to exceed 2 inches at the time of concrete placement.

2. Remove the temporary casing, if present. During extraction of the casing, prevent upward movement of the steel soldier pile.

3. Vibrate only the top 5 feet of concrete after the casing has been withdrawn.

3.04 LAGGING

A. Install lagging as excavation progresses.

B. Do not allow more than 4 feet of exposed cut soil face.
C. Backfill lagging with free-draining material as lagging is installed. Backfill lagging prior to excavating subsequent lift.

D. Take immediate steps to prevent piping of soils through lagging if observed.

3.05 SUPPORT SYSTEMS WITH INTERNAL BRACING

A. General: Provide wales, struts, and rakers as necessary to support excavation faces retained by soldier piles and lagging, or by tangent-piles.

B. Bracing:
   1. Provide wales where required, at each level of bracing. As excavation proceeds, place wales on open face of support system wall. Wedge, dry pack, and otherwise provide tight bearing between wales and support system wall, with ample bearing areas to provide uniform transfer of loads.
   2. Include web stiffeners, plates, angles, or bracing as needed to prevent rotation, crippling, or buckling of connections and points of bearing between structural members. Allow for eccentricities caused by field fabrication and assembly.
   3. Design bracing support members for maximum loads which may occur during excavation and removal stages.

3.06 PILE BRACING

A. Steel bracing may be required during tieback stressing and testing to restrain the soldier pile from twisting. The locations and configuration of the bracing will be determined in the field at the time of construction. The cost to furnish the bracing will be considered incidental.

3.07 EXCAVATION BELOW TIEBACKS AND BRACING

A. Tieback, wale, strut and raker installation testing and stressing shall be completed prior to excavating more than 2 feet below centerline of tieback or bracing level.

3.08 TOLERANCES

A. Soldier Piles and Sheet Piles:
   1. Install tops of soldier piles and sheet piles within 3 inches, plus or minus, horizontally of the locations shown on the approved Working Drawings or Contract Drawings.
   2. Install tops of soldier piles and sheet piles within 6 inches, plus or minus, vertically of the locations shown on the approved Working Drawings or Contract Drawings.
   3. Install steel soldier piles and sheet piles within 1.5 percent of plumb.

3.09 REMOVAL OF EXCAVATION SUPPORT SYSTEMS

A. Removal of excavation support systems includes removal of excavation support elements installed by the N125 contract.
B. If removal is required wholly or in part, perform such removal in a manner that will not disturb or damage adjacent structures, construction, or utilities. Fill voids immediately with lean concrete or with approved backfill compacted to the relative compaction for the location as specified in Section 31 20 00, Earth Moving.

C. Leave excavation support systems in place until the concrete and structures to receive the transferred loading from the removed support system have reached the specified 28-day compressive strength. Demonstrate by methods acceptable to Resident Engineer that the concrete has reached the specified strength before load transfer from the support system to the concrete structure may be performed. Do not remove bracing supporting pile caps or base slabs for a minimum 7 days after last concrete has been placed.

D. Remove from the Site all elements of excavation support systems 4 feet below the level of surfaces to be constructed or restored.

E. Repair damage to new or existing structures resulting from removal of excavation support systems.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for designing, furnishing, installing, maintaining, and leaving in place a temporary tieback retaining wall as indicated on the Contract Drawings. Coordinate requirements of this Section with Section 31 50 00, Excavation Support and Protection.

B. Unless otherwise directed, the Contractor shall select the tieback type, drilling method, grouting method, grouting pressures, and, subject to the minimum values in the Contract Drawings, determine the bond length, free-stressing (unbonded) length, and anchor diameter. The Contractor shall be responsible for installing tiebacks that will develop the load-carrying capacity indicated on the Contract Drawings in accordance with the testing subsection of this Section.

C. The work of this Section includes the following:

1. Install temporary tiebacks as required as excavation proceeds.

D. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 03 05 15, Portland Cement Concrete
2. Section 03 11 00, Concrete Forming
3. Section 03 20 00, Concrete Reinforcing
4. Section 03 30 00, Cast-In-Place Concrete
5. Section 31 50 00, Excavation Support and Protection

1.02 REFERENCES

A. This Section incorporates by reference the latest revision of the following documents.

   b. ASTM A500 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   c. ASTM A775 Standard Specification for Epoxy-Coated Steel Reinforcing Bars
2. American Association of State Highway and Transportation Officials (AASHTO):
   a. AASHTO M85 Portland Cement
   b. AASHTO M183 Structural Steel
   c. AASHTO M203 Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement
   d. AASHTO M222 High-Strength Low-Alloy Structural Steel with 50 ksi Minimum-Yield Point to 4-in Thick
   e. AASHTO M252 Corrugated Polyethylene Drainage Pipe
   f. AASHTO M275 Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
   g. AASHTO M284 Standard Specification for Epoxy-Coated Steel Reinforcing Bars

3. Post-Tensioning Institute (PTI):
   a. Recommendations for Prestressed Rock and Soil Anchors
   b. Post-Tensioning Manual

1.03 DEFINITIONS

A. Anchor Tieback: System used to transfer tensile loads to soil or rock. Includes all prestressing steel, centralizers, spacers, anchorage devices, grout, coatings, sheathings, and couplers if used.

B. Soldier Piles: Steel shapes installed vertically to take the thrust of horizontal lagging. Also called soldier beams.

C. Tremie Concrete: Concrete placed by means of tremie equipment, for depositing concrete under water and thereby displacing water in an excavation.
D. Waler: Horizontal beam used to brace or support vertical sheeting or piling.

E. Alignment Load: A nominal minimum load applied to a tieback anchor during testing to keep the testing equipment correctly positioned.

F. Bondbreaker: A sleeve placed over the anchor tendon in the free-stressing (unbonded) length to ensure unobstructed elongation of the tendon during stressing.

G. Encapsulation: A corrugated or deformed tube protecting the prestressing steel against corrosion in the tendon bond length.

H. Tendon: The complete anchor assembly (excluding grout) including prestressing steel (strands or bar), corrosion protection, sheathings, coatings, and spacers and centralizers.

I. Bond Length: The length of the tieback anchor that is bonded to the surrounding soil and capable of transmitting the applied tensile load to the soil.

J. Tendon Bond Length: The length of the tendon that is bonded to the surrounding grout and capable of transmitting the applied tensile load to the grout.

K. Unbonded Length: The designed length of the tendon that is not bonded to the grout during stressing.

L. Working Drawings: See 31 50 00, Excavation Support and Protection.

M. Centralizers: Support the tendon in the drill hole and position the tendon so grout freely flows around tendon and up drill hole.

N. Spacers: Separate the steel strands of strand tendons.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Calculations for design of the tendons, unbonded lengths, bonded lengths, bearing plates, bearing stiffeners, and wedge plates for review and approval prior to commencement of this work. Ensure calculations are prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of Washington.

C. Working drawings indicating tieback system and installation procedures including:

1. Anchor tieback schedule showing each tieback number, design load, tendon type and size of anchor, minimum total anchor length, minimum bond length, minimum tendon bond length, and minimum unbonded length.

2. Drawings for tendons including details for spacers and locations, centralizers and locations, and anchorage and trumpet.

D. Grout mix design.

E. Mill test reports for prestressing steel and bearing plate steel.

F. Calibration data for each test jack, load cell, primary pressure gage, and reference pressure gage to be used. Calibration records shall include the date tested, the device identification number and the calibration test results, and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 calendar days prior to submittal.
G. Grouting records indicating cement type, quantity injected, and grout pressures; anchor test results and graphs, and as-builts showing location and orientation of each tieback anchor, anchor capacity, tendon type, total anchor length, tendon bond length, and locations of all instruments.

H. Provide test data and results for all testing as required herein.

I. Driller’s qualifications.

J. Anchor tieback design engineer’s qualifications.

1.05 QUALITY ASSURANCE

A. Drillers shall be skilled in tieback installation work, for the purpose of drilling and installing tiebacks, and have a minimum of five years of experience in drilling and installing work of similar scope and complexity.

B. Anchor Tieback Design Engineer shall be a professional civil or structural engineer currently registered in the State of Washington.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Handle and store tendons in such a manner as to avoid damage or corrosion. Damage to prestressing steel as a result of abrasions, cuts, nicks, welds, and weld spatter will be cause for rejection.

B. Protect prestressing steel if welding is to be performed in vicinity. Grounding of welding leads to prestressing steel is forbidden. Protect prestressing steel from dirt, rust, deleterious substances, or excessive heat. A light coating of rust on steel is acceptable. If heavy corrosion or pitting is noted, Resident Engineer will reject affected tendons.

C. Do not cause excessive bending during lifting of pre-grouted tendons, which can de-bond the prestressing steel from the surrounding grout.

D. Tendon bond length must be free of dirt, manufacturer’s lubricants, corrosion inhibiting coatings or other deleterious substances that may significantly affect the grout tendon bond.

1.07 PROJECT CONDITIONS

A. Refer to Geotechnical Conditions Summary (Appendix A).

B. Existing Utilities: Verify location of existing utilities prior to commencement of excavation activities. Proceed with caution in areas of utility facilities and structures. Expose existing utilities by hand-excavation or by other method acceptable to the utility owner.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Use new materials that are sound and free from strength-impairing defects.

B. Soldier Piles: In accordance Section 31 50 00, Excavation Support and Protection.

C. Steel Wales: In accordance Section 31 50 00, Excavation Support and Protection.

D. Ensure tieback system materials meet the following requirements:
1. Anchorage Devices:
   a. Stressing Anchorages: Combination of either a steel bearing plate with wedge plate and wedges, or a steel bearing plate with a threaded anchor nut. The steel bearing and wedge plate may also be combined into a single element. Ensure anchorage devices are capable of developing 95 percent of the specified minimum ultimate tensile strength of the prestressing steel tendon. Ensure anchorage devices conform to the static strength requirements of the PTI Post Tensioning Manual.
   b. Bearing Plates: Conform to the requirements of AASHTO M183 or M222 or approved equal.

E. Wedges: Design to preclude premature failure of prestressing steel due to notch or pinching effects under static and dynamic strength requirements of the PTI Post-Tensioning Manual. Do not reuse wedges.

F. Bondbreakers: Fabricate from smooth plastic tube or pipe having the following properties:
   a. Resistant to chemical attack from aggressive environments, grout or corrosion inhibiting compound;
   b. Resistant to aging by ultra-violet light;
   c. Fabricated from material non-detrimental to tendon;
   d. Capable of withstanding abrasion, impact, and bending during handling and installation;
   e. Enables tendon to elongate during testing and stressing;
   f. Allows tendon to remain unbonded after lock-off.

G. Cement Grout: Type I, II, III, or V portland cement conforming to the requirements of AASHTO M85. Use grout of a pumpable neat mixture of cement and water and that is stable (bleeds less than 2 percent), fluid, and provides a minimum 28-day compressive strength of at least 4000 pounds per square inch (psi) measured in accordance with ASTM C109 at time of stressing. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout. Ensure admixtures are compatible with the prestressing steels and mixed in accordance with manufacturer's recommendations. Expansive admixtures may only be added to grout used for filling sealed encapsulations, trumpets, and anchorage covers.

H. Centralizers and Spacers: Plastic or material non-detrimental to prestressing steel.

I. Corrosion-Inhibiting Compound: For the corrosion-inhibiting compound placed inside the sheath in the free length, use an organic compound such as wax or grease with appropriate polar material displacing, corrosion-inhibiting additives and self-healing properties. Use a compound that permanently stays viscous and is chemically stable and non-reactive with the prestressing steel, the sheathing materials, and the anchor grout.

J. Grout Tubes: Have adequate inside diameter to enable grout to be pumped to bottom of drill hole. Strong enough to withstand grouting pressures.

K. Prestressing Steel: Fabricate from single or multiple elements of one of the following prestressing steels:
a. Steel bars conforming to AASHTO M275

b. Seven-wire, low-relaxation strands conforming to AASHTO M203

c. Compact seven-wire, low-relaxation strands conforming to ASTM A779

L. Couplers: capable of developing 100 percent of minimum specified ultimate tensile strength of prestressing steel bar.

M. Sheath: Use as part of the corrosion protection system for the unbonded length portion of the tendon. Fabricate from one of the following:

1. A polyethylene tube pulled or pushed over the prestressing steel. Use Type II, III, or IV polyethylene as defined by ASTM D1248, or approved equal. Use a tubing that has a minimum wall thickness of 1/16 inch.

2. A hot-melt extruded polypropylene tube. Use cell classification B55542-11 polypropylene as defined by ASTM D4101, or approved equal. Use tubing that has a minimum wall thickness of 1/16 inch.

3. A hot-melt extruded polyethylene tube. Use high density Type III polyethylene as defined by ASTM D1248, or approved equal. Use tubing that has a minimum wall thickness of 1/16 inch.

4. Steel tubing conforming to ASTM A500. Use tubing that has a minimum wall thickness of 3/16 inch.

5. Steel pipe conforming to ASTM A53. Use pipe that has a minimum wall thickness of 3/16 inch.

6. Plastic pipe or tube of PVC conforming to ASTM D1784 Class 13464-B. Use pipe or tube that is Schedule 40 at a minimum.

7. A corrugated tube conforming to the requirement of the tendon bond length encapsulation.

N. Concrete and Grout: Refer to Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, Section 03 30 00, Cast-In-Place Concrete, and Section 03 05 15, Portland Cement Concrete, for requirements.

PART 3 - EXECUTION

3.01 GENERAL

A. Install soldier pile excavation support wall for safety and preservation of existing improvements, as specified in Section 31 50 00, Excavation Support and Protection.

B. No part of the tieback wall will be allowed to intrude within the limits of permanent structures.

3.02 FIELD QUALITY CONTROL

A. Anchor Tieback installation: Retain the services of a geotechnical engineer to observe the installation, including observation and recording of tests.
3.03 TIEBACK TENDON DESIGN CRITERIA

A. Refer to Section 31 50 00, Excavation Support and Protection, for system design requirements.

B. Determine bond length necessary to develop design load indicated on Contract Drawings or in approved working drawings. Install a minimum bond length of 15 feet for strand and bar tendons.

C. Extend the free stressing length (unbonded length) for tiebacks beyond the no load zone as shown on the Contract Drawings.

D. Ensure all anchors are capable of being re-stressed as required.

3.04 FABRICATION

A. Shop or field-fabricate tiebacks. Cut prestressing steel with abrasive saw or, with approval of prestressing steel Supplier, an oxyacetylene torch.

3.05 INSTALLATION

A. Select the drilling method, grouting procedure, and grouting pressure to be used for installation of anchors as necessary to satisfy load test requirements.

B. Locate drill hole such that longitudinal axis of drill hole and longitudinal axis of tendon are parallel. Do not drill hole in a location that requires tendon to be bent in order for bearing plate to be connected to supported structure.

C. Prior to inserting tendon in drill hole, examine tendon for damage to encapsulation and sheathing. If required, repair encapsulation in accordance with Supplier’s recommendations. Repair damage to sheathing with high molecular weight polyethylene tape. Spiral wind the tape around the tendon to completely seal damaged area. Spiral wind at a pitch which ensures double thickness at all points.

D. Locate tendon in the middle third of the anchor section.

E. Where centralizers are required, space them at no greater than 10 feet on center with the deepest centralizer located one foot from the end of the anchor and the upper centralizer for the bond zone located no more than five feet from the top of the tendon bond length.

F. Ensure spacers permit grout to freely flow around tendon and up drill hole. Place spacers at a maximum interval of 10 feet.

G. Place tendons in accordance with recommendation of tendon manufacturer. Insert tendon in drill hole to desired depth without difficulty. Do not drive or force partially inserted tendons into drill hole. Remove tendon from drill hole and clean or redrill the hole to permit insertion.

H. Control the rate of placement of tendon into drill hole such that sheathing and grout tubes are not damaged during installation of tendon. Do not subject anchor tendons to sharp bends. Bottom end of tendon may be fitted with a cap or bullnose to aid its insertion into the hole, casing, or sheathing.

I. Drill holes for tiebacks in a manner that will minimize loss of ground and at the locations and to the length, inclination, and diameter shown on Contract Drawings or approved working drawings.
3.06 GROUTING

A. Use a neat cement grout or sand-cement grout. Ensure cement does not contain lumps or other indications of hydration. Use grouting equipment that produces grout free of lumps and undispersed cement.

B. Use a positive displacement grout pump. Equip the pump with a pressure gage to monitor grout pressures. Ensure pressure gage is capable of measuring pressures of at least 150 pounds per square inch or twice the actual grout pressure used whichever is greater. Size grouting equipment to enable grout to be pumped in one continuous operation. Ensure mixer is capable of continuously agitating the grout.

C. Inject grout from lowest point of drill hole. Pump through grout tubes, casing, hollow-stem augers, or drill rods. Place before or after insertion of tendon. Record quantity of grout and grout pressures. Control grout pressures and grout takes to prevent excessive heave or fracturing.

D. Do not use pressure grouting in free length zone. Ensure the grout at the top of the drill hole does not contact the back of the structure or the bottom of the trumpet.

E. Do not load tendon for a minimum of three days after grouting. Clean and protect stressing tail from damage until lock-off. After anchor has been stressed and accepted by the Resident Engineer, cut tail to final length according to tendon manufacturer's recommendations.

F. Install anchor bearing plate and anchor head or nut perpendicular to tendon, within plus or minus three degrees and centered on bearing plate, without bending or kinking of prestressing steel elements. Ensure wedge holes and wedges are free of rust, grout, and dirt.

3.07 STRESSING, LOAD TESTING, AND ACCEPTANCE OF TIEBACKS

A. Test each tieback anchor. Do not apply a load greater than 10 percent of the design load to the anchor prior to testing. Do not apply a maximum test load greater than 80 percent of the specified minimum ultimate tensile strength of the prestressing steel of the tendon. Simultaneously apply test loads to the entire tendon. Stressing of single elements of multi-element tendons is not permitted.

B. Test Equipment

1. Use a dial gage or vernier scale capable of measuring displacement to 0.001 inch to measure tendon movement. Ensure it has adequate travel so total movement can be measured without resetting the device.

2. Use a hydraulic jack and pump to apply the test load. Use the jack and a calibrated pressure gage to measure the applied load. Use a pressure gauge that is graduated in 100 psi increments or less. When the theoretical elastic elongation of the total anchor length at the maximum test load exceeds the ram travel of the jack, include the procedure for recycling the jack ram in the working drawings. Apply each increment of test load in one minute or less.

3. Maintain a calibrated reference pressure gage at the site. Calibrate the reference gage with the test jack and pressure gage.

4. Provide an electrical resistance load cell and readout when performing a creep test.
5. Place the stressing equipment over the tendon in such a manner that the jack, bearing plates, load cell, and stressing anchorage are axially aligned with the tendon and the tendon is centered within the equipment.

C. Performance Test

1. Conduct successful performance tests on at least two tieback anchors, as selected by the Resident Engineer. The contractor should anticipate that up to 8 performance tests may be required. Drill and install the performance test anchors in the same manner as the production anchors, with the exception that additional or larger tendons should be included so that the test load does not exceed 80 percent of the specified minimum ultimate tensile strength of the prestressing steel of the tendon. Changes in methods, personnel, materials or equipment may require additional performance testing as determined by the Resident Engineer.

2. Performance test selected anchors as indicated in the following schedule. Adhere to the following schedule. Raise load from one increment to another immediately after recording tendon movement.

3. Measure and record tendon movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each increment of load. Monitor load with a pressure gage. Place reference pressure gage in series with the pressure gage during each performance test. If load determined by reference pressure gage and load determined by pressure gage differ by more than 10 percent, recalibrate the jack, pressure gage, and reference pressure gage. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

PERFORMANCE TEST SCHEDULE

<table>
<thead>
<tr>
<th>Load</th>
<th>Load (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment Load (AL)</td>
<td>AL</td>
</tr>
<tr>
<td>0.25P*</td>
<td>0.25P</td>
</tr>
<tr>
<td>AL</td>
<td>0.50P</td>
</tr>
<tr>
<td>0.25P</td>
<td>0.75P</td>
</tr>
<tr>
<td>0.50P*</td>
<td>1.00P</td>
</tr>
<tr>
<td>AL</td>
<td>1.50P*</td>
</tr>
<tr>
<td>0.25P</td>
<td>AL</td>
</tr>
<tr>
<td>0.50P</td>
<td>0.25P</td>
</tr>
<tr>
<td>0.75P*</td>
<td>0.50P</td>
</tr>
<tr>
<td>AL</td>
<td>0.75P</td>
</tr>
<tr>
<td>0.25P</td>
<td>1.00P</td>
</tr>
<tr>
<td>0.50P</td>
<td>1.50P</td>
</tr>
<tr>
<td>0.75P</td>
<td>2.00P* = Maximum performance test load</td>
</tr>
<tr>
<td>1.00P*</td>
<td>Reduce to lock-off load (0.80P)</td>
</tr>
</tbody>
</table>

* = Graph required, as specified herein.
AL = alignment load
P = design load
4. Record the anchor movement relative to the fixed reference point for the maximum performance test load at 0 time, 30 seconds, 1 minute, 2 minutes, 3 minutes, 5 minutes, 6 minutes, and 10 minutes. Also record at 20 minutes, 30 minutes, 50 minutes and 60 minutes if creep criteria are not met at 10-minute interval. Re-pump the jack as necessary in order to maintain a constant load.

5. Creep Criteria are as follows:
   a. Total anchor movement between the 1 and 10-minute intervals should not exceed 0.04 inches.
   b. Total anchor movement between the 6 and 60-minute intervals (if required) should not exceed 0.08 inch.

6. Construct a graph showing a plot of anchor movement versus load for each load increment marked with an asterisk (*) in the performance test schedule, and a plot of the residual anchor movement at each alignment load versus the highest previously applied load. Submit graph format to the Resident Engineer prior to use.

D. Proof Test

1. Proof-test all production anchors as indicated in the following schedule. Raise the load from one increment to another immediately after recording of the tendon movement.

2. PROOF TEST SCHEDULE

<table>
<thead>
<tr>
<th>Load</th>
<th>Alignment Load (AL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25P</td>
<td>0.25P</td>
</tr>
<tr>
<td>0.50P</td>
<td>0.50P</td>
</tr>
<tr>
<td>0.75P</td>
<td>0.75P</td>
</tr>
<tr>
<td>1.00P</td>
<td>1.00P</td>
</tr>
<tr>
<td>1.20P</td>
<td>1.20P</td>
</tr>
<tr>
<td>1.33P = Maximum proof test load; Evaluate creep</td>
<td></td>
</tr>
<tr>
<td>Reduce to lock-off load (0.80P)</td>
<td></td>
</tr>
</tbody>
</table>

P = design load

3. After reaching the maximum proof test load of 1.33P, maintain the load for 10 minutes to evaluate creep based on the observed deflection behavior. Record measurements at 0 time, 30 seconds, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, 6 minutes and 10 minutes. If the movement between the 1 minute and 10 minute hold is equal to or exceeds the creep criteria, maintain the load for an additional 50 minutes. Record measurements at 20 minutes, 30 minutes, 50 minutes and 60 minutes.

4. Creep Criteria are as follows:
   a. Total anchor movement between the 1 and 10-minute intervals should not exceed 0.04 inch.
   b. Total anchor movement between the 6 and 60-minute intervals (if required) should not exceed 0.08 inch.
5. Measure and record the tendon movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each increment of load. Use the pressure gage and reference pressure gage to measure the applied load, and use the load cell to monitor small changes of load during the constant load-hold period. Re-pump the jack as necessary to maintain the constant load.

6. Compare the results of the proof tests to the results of the performance tests. If any significant variation from the performance test is observed, as determined by the Resident Engineer, re-evaluate the design capacity of this and subsequent anchors.

E. Load Test Acceptance Criteria

1. Evaluate the results of each anchor test in order to determine anchor acceptability. An anchor will be acceptable provided:
   a. The total movement obtained from a performance and proof test exceeds 80 percent of the theoretical elastic elongation of the design free stressing length.
   b. The measured creep rate during the proof test load does not exceed the specified creep criteria and is a linear or decreasing creep rate, regardless of tendon length and load.

2. Reload anchors that do not meet the first acceptance criterion up to two times from Alignment Load to Test Load and repeat the calculation on these cycles. If the criterion is still not met, do not incorporate the tieback into the wall unless detensioned to prevent transfer of load to the no-load zone. Anchors that do not meet the second acceptance criterion cannot be incorporated into the wall at their design load, but may be accepted at a lesser load either determined from other production tests or additional tests. Lock off anchors that satisfy the acceptance criteria at the design lock-off load, which is 80 percent of the tieback anchor design load.

3. When a tendon fails, modify the design or installation procedures. The modifications may include, but are not limited to, installing a replacement tendon, reducing design load by increasing the number of tendons, modifying the installation methods, increasing the bond length or changing the anchor type. Submit modifications that require changes to the structure for review to the Resident Engineer.

4. Retesting of anchors will not be permitted, except that re-grouted tendons may be retested.

3.08 TOLERANCES

A. Deviation of anchor projection angle shall be not more than 2 degrees vertically and horizontally.

B. Locate the exposed end of the tieback within 6 inches of the location shown on the Contract Drawings of approved Working Drawings.

C. Anchor clearance to existing utilities or foundations shall be not less than 3 feet.
3.09 TIEBACK REMOVAL

A. De-tension temporary tiebacks in sequence with completion of permanent structure or backfill as follows:

1. De-tension tiebacks from the N125 support of excavation contract in the sequence shown on the contract drawings.

2. Where permanent concrete walls are in direct contact with tieback shoring walls, allow concrete to attain design strength and obtain approval from Resident Engineer prior to de-tensioning tiebacks. Leave openings in walls as necessary to provide access to tieback for de-tensioning where shown on the contract drawings.

3. Where backfill is placed in direct contact with excavation support system, de-tension tiebacks after compacted backfill is placed against piles to within no more than 2 feet below center of tieback elevation.

END OF SECTION
SECTION 32 11 23
AGGREGATE BASE COURSES

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing, spreading, and compacting aggregate for aggregate base course as indicated.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work:
   1. Section 31 20 00, Earth Moving

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. City of Seattle (COS):
      a. Standard Specifications for Road, Bridge and Municipal Construction
      b. Standard Plans for Municipal Construction
      a. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
      b. ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. List source location of materials and all tests and certifications necessary to determine compliance with the specifications.
C. Test Reports: Submit plant and field test reports as specified in Articles 2.02 and 3.04 herein.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Mineral Aggregate Type (No.): Type as indicated on the Contract Drawings. Conform to the COS Standard Specifications Section 9-03.
2.02 SOURCE QUALITY CONTROL

A. Perform sampling and tests of the aggregate base material in accordance with the COS Standard Specifications Section 9-03.15.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Subgrade Examination

1. Call for an inspection by the Resident Engineer and obtain written acceptance of the prepared subgrade before proceeding with the placement of aggregate base course.

3.02 PREPARATION

A. Perform subgrade preparation in accordance with the Contract Drawings and in close conformity with the lines, grades, and typical cross sections indicated, as referenced in a City of Seattle Standard Plan.

B. Subgrade preparation: Section 31 20 00, Earth Moving.

3.03 CONSTRUCTION

A. Uniformly spread base material upon the prepared subgrade to the depth, width, and cross-section shown in the Contract Drawings or as referenced in a COS Standard Plan.

B. Construct in accordance with COS Standard Specifications Section 4-04.3.

3.04 FIELD QUALITY CONTROL

A. Test for compliance with specified requirements for in-place density and water content in accordance with ASTM D6938.

B. Moisture content shall not vary more than 3 percent above or below the optimum moisture content as determined by test method ASTM D1557.

C. Independently test each material type and/or when a material source changes.

D. Tolerances: Maximum allowable deviation in measured thickness of Aggregate Base Course surfacing is 1/2 inch less than specified depth.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for providing and placing Hot Mix Asphalt (HMA) on a prepared base in accordance with the lines, grades, thicknesses, and typical cross-sections shown on the Contract Drawings.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 31 20 00, Earth Moving
2. Section 32 11 23, Aggregate Base Courses

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. City of Seattle (COS):
   a. Standard Specifications for Road, Bridge, and Municipal Construction
   b. Standard Plans for Municipal Construction

2. Seattle Department of Transportation (SDOT):
   a. Seattle Department of Transportation, Director’s Rule 5-2009: Street and Sidewalk Pavement Opening and Restoration

1.03 DEFINITIONS

A. Hot Mix Asphalt (HMA): A plant-mixed asphalt concrete pavement composed of asphalt binder and mineral aggregate mixed in specified proportions at a predetermined temperature to provide a homogenous, stable, workable, and compactable mixture.

B. Asphalt Treated Base (ATB): A dense-graded HMA consisting of a compacted course of base material which has been weatherproofed and stabilized by treatment with an asphalt binder.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Mix Design: Comply with the COS Standard Specification Section 5-04.3(6) for mix design submittal requirements.

C. Paving Plan for areas under traffic: COS Standard Specification Section 5-04.3(17).
D. Test Reports: Submit test results of sampling and testing, and inspection records within 24 hours of asphalt concrete placement.

PART 2 - PRODUCTS

2.01 MATERIALS
C. Asphalt binder grade: PG 64-22 as defined in COS Standard Specification Section 9-02.1(4).
D. Tack Coat: CSS-1, CSS-1h, or STE-1 emulsified asphalt per COS Standard Specification Section 9-02.1(6).
E. Anti-stripping additive: COS Standard Specification Section 9-02.4

2.02 MIXES
A. Mix Design for HMA including ATB: COS Standard Specification Section 5-04.3(6).
B. The nominal maximum aggregate size is as indicated on the Contract Drawings. Where aggregate size is not indicated it shall be ½-inch maximum.
C. Parking Lot paving: Follow the requirements of the “Structural application-minor quantity” as defined in the COS Standard Specifications Section 5-04.3(6).
D. Sidewalk paving: follow the requirements of the “Non-structural application” as defined in the COS Standard Specifications Section 5-04.3(6).
E. Asphalt binder: PG 64-22. The Contractor may propose the substitution of alternate grades of performance grade (PG) asphalt binder at no cost to Sound Transit as specified in COS Standard Specifications Section 5.04.2(1).

2.03 SOURCE QUALITY CONTROL
1. Acceptance Sampling and Testing of HMA: COS Standard Specifications Section 5-04.3(7)B.
2. Aggregates for ATB: Testing requirements in accordance with COS Standard Specification Section 9-03.6(3).
3. Aggregates for Hot Mix Asphalt: Test Requirements in accordance with COS Standard Specification Section 9-03.8(2).

PART 3 - EXECUTION

3.01 PREPARATION
A. Prepare subgrade for surfacing in accordance with Section 31 20 00, Earth Moving.
B. Construct Aggregate Base Course surfacing where indicated in accordance with Section 32 11 23, Aggregate Base Courses.
C. Surface Preparation:
   1. Preparation of street surfaces shall be in accordance with COS Standard Specification Section 5-04.3(4)

D. Surface preparation of aggregate bases or native subgrade: COS Standard Specifications Section 5-04.3(4)C.

3.02 CONSTRUCTION

A. Provide asphalt concrete pavement in accordance with the layout, configurations, and dimensions indicated on the Contract Drawings or in a referenced COS Standard Plan.

B. Construct HMA asphalt concrete pavement in conformance with the COS Standard Specifications Section 5-04.3.

C. Construct ATB in conformance with COS Standard Specification Section 4-06.

D. For asphalt concrete pavement patching within the City of Seattle right-of-way, comply with the COS Director’s Rule 5-2009: Street and Sidewalk Pavement Opening and Restoration.

3.03 FIELD QUALITY CONTROL

A. Compaction Requirements and Test Results for HMA: COS Standard Specifications Section 5-04.3(9). Note thickness of asphalt tested for each testing location.

B. Compaction and Density for ATB in accordance with COS Standard Specification Section 4-06.3(7).


D. Surface Smoothness ATB: Final course of asphalt treated base shall not deviate at any point more than 3/8-inch from the bottom edge of a 10-foot straightedge laid on the surface in any direction.

3.04 MAINTENANCE OF PAVEMENT

A. Allow newly compacted asphalt to cool to ambient temperature before any traffic is allowed on it. Do not allow traffic on the newly placed asphalt until approval has been obtained from the Resident Engineer.

B. Maintain finished pavement in finished clean condition until the work is accepted by the Resident Engineer.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for providing Portland cement concrete pavement for roadways, driveways, sidewalks, and concrete patching as indicated.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.
   1. Section 31 20 00, Earth Moving
   2. Section 32 11 23, Aggregate Base Courses

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
   1. City of Seattle (COS):
      a. Standard Specifications for Road, Bridge and Municipal Construction
      b. Standard Plans for Municipal Construction
   2. Seattle Department of Transportation (SDOT):
      a. SDOT Director’s Rule 5-2009: Street and Sidewalk Pavement Opening and Restoration

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: Submit manufacturers' product data for proposed concrete admixtures.

C. Concrete Mix Designs: Submit mix designs as specified in City of Seattle Standard Specifications Section 5-05. Include Manufacturer’s Certificate of Compliance indicating the batch weights. Submit mix design to the Resident Engineer including mix proportions per cubic yard, proposed sources, volume of entrained air, average 28 day Compressive Strength, water cement ratio, fineness modulus, and aggregate proportions.

D. Detectable warning plate for curb ramps: Submit the information required in COS Standard Specification Section 8-14.3(7)B to the Resident Engineer at least 5 Working Days in advance of placement.

E. Shop Drawings:
   1. Submit drawings showing the locations of all joints in concrete, including construction joints, expansion joints, isolation joints, and contraction joints.
2. Submit drawings indicating concrete placement method, sequence, location, and boundaries. Include each type and class of concrete, and quantity in cubic yards.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Use materials in construction of cement concrete pavements, including but not limited to Portland cement, aggregates, reinforcing steel, curing materials and admixtures as specified in the COS Standard Specifications Section 5-05.2.

2.02 MIXES

A. Provide the class of concrete as indicated on the Contract Drawings. Provide a mix design for each class of concrete used. Proportion mixes as specified in COS Standard Specification Section 5-05.3(1).

B. Where class of concrete is not indicated on the Contract Drawings the following apply:

1. Concrete mix for arterial pavement: Class 6.5 (1-1/2)
2. Concrete mix for residential streets and alleys: Class 6 (1-1/2).

C. Submit concrete mix designs to the Resident Engineer in advance of ordering leaving sufficient review time as specified in Section 01 33 00, Submittal Procedures.

D. Concrete placeability, workability, and strength shall be the responsibility of the Contractor.

E. Nominal maximum size for concrete aggregate is defined as the smallest standard sieve opening through which the entire amount of the aggregate is permitted to pass.

2.03 SOURCE QUALITY CONTROL

A. Testing and Analysis:

1. Perform all testing and analysis of materials used in accordance with COS Standard Specifications Section 5-05 and Section 9.

PART 3 - EXECUTION

3.01 PREPARATION

A. Prepare subgrade for surfacing per Section 31 20 00, Earth Moving.

B. Construct Aggregate Base Course surfacing where indicated in accordance with Section 32 11 23, Aggregate Base Courses.

3.02 CONSTRUCTION

A. General
1. Construct Portland cement concrete pavement in accordance with the lines, grades, thicknesses, and typical cross-sections indicated on the Contract Drawings or in a referenced COS Standard Plan. Remove and replace pavement that is not within the allowable tolerances for line, grade, thickness and cross-section.

2. Construct Portland cement concrete pavements for roadways and pavement patching in accordance with the requirements of the COS Standard Specifications Section 5-05.3.

3. Construct Portland cement concrete sidewalks, and curb ramps in accordance with COS Standard Specifications Section 8-14.3.


5. Portland cement concrete pavement and sidewalk patching from trenching activities within the City right-of-way shall also comply with the City of Seattle’s Directors Rule 5-2009: Street and Sidewalk Pavement Opening and Restoration.

3.03 FIELD QUALITY CONTROL:

A. Concrete Testing: Perform all acceptance testing of concrete pavement for roadways as specified in the COS Standard Specifications, Section 5-05.

B. Opening Pavements to Traffic:

1. Comply with the requirements for pavement opening specified in the COS Standard Specifications Section 5-05.3(17).

2. Do not open newly constructed pavements to traffic until the Resident Engineer has given approval.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

  A. This Section includes specifications for installing new Unit Pavers.

  B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

     1. Section 31 20 00, Earth Moving.

     2. Section 32 11 23, Aggregate Base Courses.

     3. Section 32 13 13, Concrete Paving.

1.02 REFERENCES

  A. This Section incorporates by reference the latest versions of the following documents.


        a. ASTM C33, Specification for Concrete Aggregates.

        b. ASTM C140, Standard Test Methods for Sampling and Testing Masonry Units and Related Units.


        d. ASTM C936, Standard Specification for Solid Concrete Interlocking Paving Units.

     2. City of Seattle (COS):

        a. Standard Specifications for Road, Bridge, and Municipal Construction.

1.03 SUBMITTALS

  A. Procedures: Section 01 33 00, Submittal Procedures.

  B. Layout Drawings: Submit layout drawings showing typical installation of pavers, including layout dimensions, field cutting and coordination of pavers with below grade vaults and utility lids.

  C. Product data for the following products:

     1. Precast Concrete Unit Pavers

  D. Samples:
1. Precast Pavers: Submit three sets of precast concrete paver samples for verification purposes. Submit sets of full size units for each of the unit paver types indicated showing color, texture and pattern specified and the full range of variations expected in these characteristics.

E. Qualification data for firms and persons specified in Article 1.04 herein to demonstrate their capabilities and experience. Include list of completed projects with project names, addresses, names of architects and owners, plus other information specified.

1.04 QUALITY ASSURANCE

A. Manufacturers Qualifications: Minimum of 5 years experience in the manufacturing of precast concrete units of quality specified.

B. Installer Qualifications: Engage an experienced installer with minimum of 5 years experience who has successfully completed unit paver installations similar in material, design, and extent to that indicated for the Contract.

C. Single Source Responsibility: Obtain each color, type and variety of unit pavers from a single source with resources to provide products and materials of consistent quality in appearance and physical properties without delaying progress of the work.

D. Tolerance: Fabrication Tolerances: Variations no more than plus or minus 1/16 inch in width, height, length, thickness, concave or convex deflection.

E. Acceptability or Appearance: The following list of finish defects is unacceptable. Replace these defects with a new unit at no additional cost to Sound Transit.

1. Pavers not being within the approved color range.
2. Non-uniformity of surface texture.
3. Foreign material embedded in the face.
4. Shrinkage cracks.
5. Ragged or irregular edges. Minor defects incidental to the usual method of manufacturer or slight chipping resulting from handling and delivery may be acceptable to the Resident Engineer provided such defects are minor in scope and do not affect the overall quality and appearance of the work.

F. Extra Stock: Furnish extra stock of quantity equal to 0.5 percent of amount installed, in full-size units, for each type, color, size and finish of tile to location specified by Resident Engineer.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver precast pavers on wood pallets, covered with non-staining waterproof membrane; allow air to circulate around precast units.

B. Handle precast units to prevent chipping, breakage, soiling or other damage. Do not use pinch or wrecking bars without protecting edges of precast units with wood or other rigid materials. Lift with wide-belt type slings wherever possible; do not use wire ropes or ropes containing tar or other substances that might cause staining. If required, use wood rollers and provide cushion at end or wood slides.
1.06 PROJECT CONDITIONS

A. Prior to commencing work on the site, record existing conditions of the unit paver areas via a video or picture record. Include any areas of pavers that may be driven on by construction equipment and areas where utility trenching will occur.

B. Review installation procedures, and coordinate with other work, and others whose work will be affected by the precast units work.

C. Cold Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Bedding Sand: gradation conforming to ASTM C33. Do not use Mason sand.

B. Joint-filling Sand: Mason Sand conforming to ASTM C144 and the following gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>ASTM C144 Natural Sand</th>
<th>ASTM C144 Manufactured Sand</th>
</tr>
</thead>
<tbody>
<tr>
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<td>100</td>
</tr>
<tr>
<td>No. 8</td>
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</tr>
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<td>No. 16</td>
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<td>2 to 15</td>
<td>10 to 25</td>
</tr>
<tr>
<td>No. 200</td>
<td>0</td>
<td>0 to 10</td>
</tr>
</tbody>
</table>

C. Unit Paver Type 1

1. Type and Manufacturer: To be determined.
   a. Color: To be determined.
   b. Dimensions: To be determined

2. Physical Properties:
   a. General: Meet the requirements of ASTM C936.
   b. Compressive Strength: Minimum 7,000 pounds per square inch (psi) at 28 days when tested in accordance with ASTM C140.
c. Water Absorption: Maximum of 5 percent when tested in accordance with ASTM C140.

d. Freeze/Thaw: Ensure pavers meet the freeze/thaw tests in accordance with Section 8 of ASTM C 67. Ensure specimens when tested have no breakage and not greater than 1 percent loss in dry weight of any individual unit when subjected to 50 cycles of freezing and thawing.

D. Geotextile: Conform to City of Seattle Standard Specification Section 9-37.2, Table 3, Separation.

PART 3 - EXECUTION

3.01 PREPARATION

A. Prepare subgrade for surfacing in accordance with Section 31 20 00, Earth Moving.

3.02 INSTALLATION

A. General

1. Do not use precast units with chips, cracks, voids, stains, or other defects that might be visible in the finished work. Before setting precast units, examine units for conformance with specified fabrication tolerances and appearance standards. Reject units not meeting requirements.

2. Use power driven masonry saws for cutting of pavers; provide clean, sharp unchipped edges; cut to provide pattern indicated and to fit adjoining work neatly; accurately form corners. Cut straight to create a 90 degrees angle to the top/bottom of the paver. Cut the top edges of all cut pavers that abut other pavers to maintain the 1/4-inch chamfer edges. Use full units without cutting wherever possible.

B. Place Aggregate Base Course in accordance with Section 32 11 23, Aggregate Base Courses.

C. Call for an inspection by the Resident Engineer and obtain written acceptance of the prepared base course before proceeding with the placement of sand bedding.

D. Geotextile: Install geotextile fabric between the aggregate base course and sand bedding.

E. Sand Bedding:

1. Spread bedding sand uniformly over the working area and screed and level to the lines and thicknesses indicated on the Contract Drawings. Screed and level the sand bed to create a loose surface. Remove, replace, and re-screed any area of bedding sand which becomes un-uniformly compacted by any means (including foot prints).

F. Paver Block Placement:

1. Place pavers on the screeded sand from the low side to the high side. Leave a 1/8 inch joint space between pavers.

G. Compaction:
1. Use a vibrating plate compactor to consolidate the pavers and sand to the finished grade.

2. Continue compaction until the level of the pavers has stabilized.

3. Use a plate compactor that has a high frequency, low amplitude vibrator with a plate surface of at least 2-1/2 square feet.

4. Compact pavers at the completion of each day’s laying.

5. Remove and replace pavers that are cracked or structurally damaged during compaction at no expense to Sound Transit.

H. Filling joints:

1. After compaction, sweep joint filling sand into the joints. Sweep away excess sand from the top surface prior to vibrating. Run a vibrating plate compactor over the pavers to work the sand into the joints. Continue the process of sweeping sand into the joints and vibrating until the joints do not accept any more sand. Repeat sand addition and vibration on a weekly basis until the joints are filled and do not accept more sand. Do not use water to wash sand into the joints.

3.03 FIELD QUALITY CONTROL

1. Vertical Installation Tolerance: Not exceeding 1/8 inch in 10 feet in any direction from level or slopes indicated when tested with a 10-foot straightedge.

2. The vertical installation tolerances also apply at the transition between existing and newly installed pavers.

3. Remove and reset pavers or paver areas which do not meet these tolerances at no additional cost to Sound Transit.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for providing cement concrete curbs.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
      a. ASTM C881, Standard Specification for Epoxy-Resin-Based Bonding Systems for Concrete
   2. City of Seattle (COS):
      a. Standard Specifications for Road, Bridge, and Municipal Construction
      b. Standard Plans for Municipal Construction

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: Submit manufacturers' product data for all materials being used.
C. Concrete Mix Design: Submit concrete mix design and test results.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Concrete for 410C and 410B curb shall be “Non-Roadway Cement Concrete” in accordance with COS Specification Section 5-05.
B. Dowels and reinforcing steel: COS Specification Section 9-07.
D. Bonding Material: Epoxy Bonding Agent meeting the requirements of COS Standard Specifications Section 9-26 and ASTM C881 for Type II epoxy resin.
PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. Construct curbs in accordance with the layout, configurations, and dimensions indicated on the Contract Drawings or as referenced in a COS Standard Plan.

B. Type 410 B &C Curb and Cement Concrete Traffic Curb

1. Construct in accordance with the referenced City of Seattle Standard Plan or as indicated and in accordance with COS Standard Specifications Section 8-04.3.

3.02 FIELD QUALITY CONTROL

A. Ensure that when checked with a 10-foot straightedge, grade does not deviate more than 1/8-inch, and alignment does not vary more than 1/4 inch.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing and installing pavement marking as indicated

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.
1. City of Seattle (COS)
   a. COS Traffic Control Manual for In-Street Work.
   c. COS Standard Specifications for Road, Bridge, and Municipal Construction.
2. Washington State Department of Transportation (WSDOT)
   a. Standard Specifications for Road, Bridge, and Municipal Construction, including applicable provisions
3. Federal Highway Administration (FHA)
   a. Manual on Uniform Traffic Control Devices (MUTCD)

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: Submit to the Resident Engineer for approval, the respective manufacturers' product data for pavement marking materials.
C. Removal: Submit to the Resident Engineer for approval, the method(s) for removing existing and temporary pavement marking(s).

PART 2 - PRODUCTS

2.01 MATERIALS
A. For pavement marking on Sound Transit owned streets, roadways, and parking lots, the materials used in the Work shall be as indicated on the Contract Drawings and conform to the applicable provisions of WSDOT 9-34, unless specified otherwise.
B. For pavement marking on City of Seattle owned streets, roadways, and parking areas, the materials used shall conform to City of Seattle Standard Specification Section 9-29.
PART 3 - EXECUTION

3.01 CONSTRUCTION

A. For pavement marking on Sound Transit owned streets, roadways, and parking lots, the work described in this Section shall be performed in accordance with the applicable provisions of WSDOT 8-22 unless specified otherwise.

B. For pavement marking on City of Seattle owned streets, roadways and parking areas, the work described in this Section shall be performed in accordance with the City of Seattle Standard Specifications Section 9-29.

C. Removal of pavement markings shall be performed by bead-blasting or other method per City of Seattle Standard Specification 2-02.3(3)J and approved by the Resident Engineer.

END OF SECTION
CONTRACT SPECIFICATIONS

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for furnishing and installing security fencing, including gates, posts, fittings, hardware, anchors, and concrete footings, as indicated.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents:
   1. Washington State Department of Transportation (WSDOT):
      a. Standard Specifications for Road, Bridge, and Municipal Construction
      b. Standard Plans for Road, Bridge, and Municipal Construction
   2. American Association of State Highway and Transportation Officials
      a. AASHTO T22 Standard Method of Test for Compressive Cylindrical Concrete Specimens
      b. AASHTO T152 Air Content of Freshly Mixed Concrete By the Pressure Method

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Product Data: Submit manufacturer's product data and specifications of the specified fencing and gates.
C. Shop Drawings: Submit detailed shop drawings of the fences and gates layout, including installation details of the fencing, posts, gates, hardware, and accessories for review.

PART 2 - PRODUCTS

2.01 MATERIALS
A. General: Supply fencing including fabric covering, framework, concrete footings, hardware, and all appurtenances and accessories as required for a complete installation. Construct fencing to heights indicated.
C. Concrete Footing: Minimum compressive strength at 28-days of 3000 psi in accordance with AASHTO T22. Air-entrain concrete with air content between 4.5-percent and 7.5-percent in accordance with AASHTO T152.

D. Post and Rails: Comply with WSDOT Standard Specification Section 9-16.1(1)A.

E. Tension Wire and Tension Cable: Comply with WSDOT Standard Specification Section 9-16.1(1)C.

F. Fittings and Hardware: Comply with WSDOT Standard Specification Section 9-16.1(1)D.

G. Chain Link Gates: Comply with WSDOT Standard Specification Section 9-16.1(1)E.

H. Barbed Wire: Comply with WSDOT Standard Specification Section 9-16.2(1)E.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Construction Requirements

1. Stake locations of fence lines, terminal posts and underground utility locations. Clear and grade with adequate clearance on both sides of the fence line.

2. Install fencing and gates in accordance with WSDOT Standard Plans and Standard Specification Section 8-12.3.

3. Concrete fill: Placed around posts to dimensions indicated and vibrated or tamped for consolidation. Protect above ground portion of posts from concrete splatter.

4. Crown top of footings to shed water.

B. Remove and Reset Fence:

1. Portions of existing chain link fence that are removed to facilitate construction and not otherwise indicated for removal shall be protected from damage during removal and storage and reinstalled to its original locations and condition.

2. Dispose of existing fence and gates, which are damaged by construction operations and replace with new fence and gates of the same or equivalent type at no additional cost to Sound Transit.

END OF SECTION
SECTION 32.84.00
PLANTING IRRIGATION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for completely automatic, electrically controlled spray and drip irrigation systems as described in Article 3.08, Exhibits herein.

B. Furnish and install equipment, materials and assemblies required for a complete and automatically controlled irrigation system.

C. This Section includes maintenance and operation of the irrigation system during the planting Warranty Period of 1 year duration to ensure the health and resumption of growth of planted materials. Refer to Section 32.90.00, Planting.

D. Irrigation piping layout is schematic. Avoid conflicts with plant materials, lighting fixtures, sign posts, site furnishings, architectural features, above and below ground utilities, and drainage systems. Locate piping in planting areas unless shown in sleeves between planting areas.

E. The system is designed to provide complete coverage with minimum maintenance and without overspray onto walks, pavements, and structures.

F. Related Sections: The Work of the following Sections is related to the Work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this Work.

   1. 
   2. Section 08.71.00, Door Hardware.
   3. Division 26, Electrical[AMS1][LC2].
   4. Section 31.20.00, Earth Moving.
   5. Section 32.90.00, Planting.

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

   1. American Society for Testing and Materials (ASTM);
      a. ASTM A53/A53M Pipe, Steel, Black and Hot-Dip Zinc-Coated, Welded and Seamless.
      b. ASTM B3 Soft or Annealed Copper Wire.
      c. ASTM B33 Tinned Soft or Annealed Copper Wire for Electrical Purposes.
      d. ASTM D1785 Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
2. American Water Works Association (AWWA):
   a. ANSI/AWWA C500 Metal Seated Gate Valves for Water Supply Service.
   b. Accepted Procedure and Practice in Cross-Connection Control Manual, published by the Pacific Northwest Section of AWWA.

3. National Electrical Manufacturers Association (NEMA):
   a. NEMA WC5 Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: Include manufacturer’s product literature for all products to be installed in this system. Include material showing manufacturer’s name, catalog numbers, catalog cuts, technical data, installation, operation, and maintenance instructions for each product.

C. Point of Connection Water Pressure Test: Test water pressure at each irrigation point of connection. Submit written results of test to the Resident Engineer.

D. Record Drawings:

1. Record accurately in red ink on 1 set of black-line prints all changes in the Work constituting departures from the Contract Drawings.

2. Record the changes and dimensions in a legible manner to the satisfaction of the Resident Engineer. Before Final Inspection of the Work, submit Record Drawings to the Resident Engineer for review.

3. Dimension from 2 permanent points of reference (buildings, monuments, sidewalks, curbs, and pavements). Record data on Record Drawings daily as the Work is being installed.

4. Show locations, depths, size, and information as applicable, of the following items:
   a. Point of connection and available static water pressure.
   b. Routing of sprinkler mainlines and lateral pipes.
   c. Sprinklers.
   d. Dripline, air/vacuum relief valves, and flush valves.
   e. Gate valves.
   f. Irrigation control valves.
   g. Quick coupling valves.
h. Routing of control wires.

i. Other irrigation system component locations necessary to accurately represent authorized changes to the irrigation system.

5. Maintain Record Drawings on site.

E. Submit Operation and Maintenance Manuals in accordance with Article 1.05B and Section 01 78 23, Operation and Maintenance [Data][AMS3][LC4].

F. Submit controller charts in accordance with Article 1.05A.

G. Submit special tools and spare parts in accordance with Article 1.05C.

1.04 SEQUENCING AND SCHEDULING

A. Schedule a Preconstruction Meeting in conjunction with the Preconstruction Meeting described in Section 32 90 00, Planting.

B. Coordinate installation of irrigation as shown on the Contract Drawings with all other Work.

C. Coordinate layout and installation of irrigation sleeves, conduits, and piping under paved areas and other features prior to their construction.

D. Coordinate installation of irrigation system with excavation of planting beds and backfilling of planting beds with topsoil. Refer to Section 32 90 00, Planting for requirements[A5].

E. Install and test the irrigation system before installation of plant material except as noted herein. Coordinate layout and installation of irrigation system with location and installation of plant material to ensure that there will be complete and full irrigation coverage of planting.

F. Stake tree locations in the field prior to installation of irrigation pipe and sprinklers. Refer to the Planting Plans and Details on the Contract Drawings for plant setbacks and spacing requirements.

G. Trees shall be located and planted prior to the installation of the irrigation system.

1.05 TURNOVER ITEMS

A. Controller Charts:

1. Record Drawings require approval by Sound Transit before charts are prepared.

2. Provide 1 irrigation zone location chart, sized to fit inside of controller door, for each automatic controller. Show the area covered by the irrigation controller.

3. The chart is a reduced copy of the Record Drawing. In the event that the controller sequence is not legible when the print is reduced, enlarge to a readable size.

4. Mark the chart with a different color to show the area of coverage for each zone.

5. When completed and accepted, hermetically seal chart between 2 pieces of transparent plastic. Install chart in controller enclosure using Velcro fasteners.
6. Complete irrigation zone location charts prior to Final Inspection.

B. Operation and Maintenance Manuals: Within 10 days prior to Final Inspection, prepare and deliver to the Resident Engineer the required descriptive materials, properly prepared in 2 individually bound copies of the operation and maintenance manual. Describe the material installed in sufficient detail to permit operating personnel to understand, operate, and maintain equipment. Include spare parts lists and related manufacturer's information for each equipment item installed. Include following information in manual:

1. Index sheet listing Contractor's address and telephone number, including names and addresses of local manufacturer's representatives.

2. Complete operating and maintenance instructions on major equipment.

3. Manuals: As specified in Section 01 78 23, Operations and Maintenance Data.

C. Special Tools and Spare Parts:

1. Supply the following items as part of Contract:
   a. 4 percent additional sprinklers and nozzles of each type and spray pattern shown on the Contract Drawings.
   b. 2 wrenches for disassembly and adjustment of each type of sprinkler head installed.
   c. 2 keys for each automatic controller.
   d. 1 coupler with 3/4 inch bronze hose bib, bent nose type with hand wheel, and 1 coupler key for each 5 quick couplers installed.
   e. 1 valve box cover key for each 10 valve boxes.
   f. Backflow device valve handles.

2. Deliver tools and spare parts to the Resident Engineer at conclusion of Final Inspection.

D. Provide the following additional documentation at close of Contract:

1. Record Drawings.

1.06 WARRANTY

A. General Warranty: The Special Warranty specified in this Section shall not deprive the Sound Transit of other rights that Sound Transit may have under other provisions of the Contract Documents, and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Make repairs and replacements and guarantee the satisfactory operation of the entire system in every detail for the 1 year Warranty Period. All warranty repairs and replacements are part of the Contract.

C. Fees:

1. Fees for normal inspections or observations by the Resident Engineer will be paid for by the Sound Transit.
2. Additional inspections, travel expenses, administrative costs and tests required because of defective work or ill-timed notices will be made at the Contractor’s expense.

D. Additional Requirements:

1. Repair settling of trenches. Restoration of plantings, mulch, grades, pavements or other improvements shall be in accordance with the Contract Documents.

2. Correct irrigation system problems or damage within 24 hours of notice until the Final Inspection of the Work.

3. During the first irrigation season, be available within 1 day for required repairs to the system.

4. Provide a written statement to the Resident Engineer stating that the Contractor shall:
   a. Warrant the satisfactory operation of the entire irrigation system including performance, parts, assemblies and workmanship.
   b. Return to the job site at the beginning of the first winter season to perform a general inspection of the system, test valves and sprinklers, repair leaks and faulty work, check operation of the system, adjust spray patterns for full coverage, drain system, show grounds staff location of drain valves and blow out points, restore areas where trenches have settled, and adjust irrigation controller scheduling if necessary.
   c. Return in spring after the first winter season for a system check and if necessary restore system for spring and summer operation. Explain system and operation methods to grounds staff and have the grounds supervisor furnish a signed statement of compliance with this requirement. Adjust automatic controller scheduling if necessary.

PART 2 - PRODUCTS

2.01 MATERIALS

A. All materials and equipment shall be new and the best grade of its kind. All items of equipment or material shall be as indicated or specified by patent or proprietary name or names of manufacturer, or accepted equal.

B. Proposed substitutions for products listed shall be submitted in accordance with Division 1.

2.02 PIPING

A. Pipe for buried irrigation systems shall be PVC except where noted otherwise.

B. PVC Pipe:


3. Schedule 80 female adapters for transition between PE and PVC Pipe.
C. PVC Threaded Nipples: 6 inches long, 1/2 inch diameter, Schedule 80, complying with ASTM D1785.

D. Sleeves: PVC pipe, Schedule 80. Sized as shown on the Contract Drawings.

E. PE Pipe: Class 160. Continuous run within sleeves.

2.03 PIPE FITTINGS


B. PE Pipe fittings: Fused polyethylene or brass internal barb fittings. For pipe diameter greater than 5/8 inch, use 2 stainless hose clamps and brass barb fittings at each joint, unless noted otherwise in the Contract Drawings.

2.04 PVC PIPE JOINT COMPOUND AND PRIMER

A. Joint compound: Slow drying, heavy-duty PVC solvent cement type, ASTM 2564.

B. Primer: Tinted, compatible with joint compound; as recommended by manufacturer of PVC pipe, ASTM 656.

2.05 IRRIGATION SPRINKLERS

A. Pop-up Bodies: Use sprinkler pop-up bodies constructed of ultraviolet resistant plastic construction, an integral check valve that holds up to 8 feet of head (3.50 psi), heavy duty retract spring, and pressure regulation capability in either the pop-up stem or under the nozzle. Use pop-up bodies with 12 inch risers, unless otherwise noted on Contract Drawings. Use Rain Bird 1800-SAM series, Hunter PRS series, Toro 570Z-XF series, or accepted equal.

B. Use sprinkler nozzles constructed of high strength, ultraviolet-resistant and impact-resistant plastic with anti-clogging valve adjustment screw for flow and radius adjustment. Use nozzles that have matched precipitation rates for individual irrigation zones. Provide adjustable arc nozzle where noted on Contract Drawings. Use rotary stream sprinkler and bubbler nozzles from Rain Bird, Hunter, Toro, or accepted equal.

C. Provide sprinklers as shown on the Contract Drawings. Use riser nipples for all sprinklers the same size as the threaded opening in the sprinkler body. Sprinklers of the same type shall be by the same manufacturer.

D. Swing Joints: as shown on the Contract Drawings.

2.06 DRIP IRRIGATION

A. Furnish all product materials required for full and efficient drip irrigation operation. All products shall be of 1 manufacturer for parts compatibility and ease of installation. Product components shall be the most current models and equipment available, and shall supersede obsolete models and equipment that may be specified in these specifications.

B. Dripline shall consist of nominal sized 1/2 inch low-density linear polyethylene tubing with internal pressure compensating, continuously self-cleaning, integral drippers spaced at 18 inches on center. Dripline shall have integral check valves. The tubing shall be brown in color and conform to an outside diameter (O.D.) of 0.67 inch and an inside diameter (I.D.) of 0.57 inch. Individual pressure compensating drippers shall be welded to the inside wall of the tubing as an integral part of the tubing assembly. These drippers shall
be constructed of plastic with a hard plastic diaphragm retainer and a self-flushing/cleaning elastomer diaphragm extending the full length of the dripper. Space dripline as indicated on Contract Drawings.

C. Header pipe downstream of the irrigation control valves shall consist of nominal sized 1/2 inch low-density linear polyethylene blank tubing. The tubing shall be brown in color and conform to an outside diameter (O.D.) of 0.67 inch and an inside diameter (I.D.) of 0.57 inch.

D. Drip Irrigation Components:
   1. Dripline Fittings: All fittings shall be constructed in one of the following end configurations: barbed insert fittings only; male pipe threads (MPT) with barbed insert fittings; or female pipe threads (FPT) with barbed insert fittings. All fittings shall be constructed of molded brown plastic having a nominal inside dimension (I.D.) of 0.57 inch. Female and male threaded ends shall be capable of mating to standard PVC pipe with tapered threads.
   2. Soil Staples: Hold dripline in place with 6 inch long steel soil staples.
   3. Automatic Flushing Valves: constructed of brown molded plastic with one of the following end configurations: 1/2 inch MPT or insert inlet with collar.
   4. Air/Vacuum Relief Valves: constructed of black and/or gray plastic with a 1/2 inch male pipe thread capable of mating with a threaded PVC reduction bushing or 1/2 inch FPT fitting.

2.07 IRRIGATION CONTROL VALVES

A. Irrigation control valves must be compatible with the controller, provided with a straight or angle pattern of either brass or bronze, and manufactured for the purpose. Control valves must meet the following requirements:
   1. Normally closed, 24-V ac, 60 Hertz solenoid actuated globe pattern diaphragm type with valve pressure rating not less than 200 psi.
   3. Actuated by a low power, 2.0 watt, 24-V ac solenoid actuator.
   4. Flow control stem and cross handle for regulating and shutting off water flow and bleed screw for manual operation without electrically energizing solenoid coil.
   5. Provide for internal parts to be removable from top of valve without disturbing valve installation.

2.08 DRIP CONTROL VALVE ASSEMBLY

A. Drip valve assemblies must be compatible with the controller, provided with a straight or angle pattern of either brass or bronze, and manufactured for the purpose:
   1. Control Valves: Normally closed, 24 VAC, 60 Hertz solenoid actuated globe pattern diaphragm type with valve pressure rating not less than 200 psi. Actuated by a low power, 2.0 watt, 24 VAC solenoid actuator. Size valves as indicated on the Drawings.
2. Control Valve Body and Bonnet: Glass-filled nylon, with nylon reinforced rubber diaphragm. Encapsulate solenoid coil in molded epoxy. Provide for internal parts to be removable from top of valve without disturbing valve installation.

3. Provide control valve with flow control stem and cross handle for regulating and shutting off water flow and bleed screw for manual operation without electrically energizing solenoid coil.

4. Pressure Regulator: The pressure regulator is a spring-operated piston-type regulator with an externally accessible regulation unit. The body is molded black plastic with a combination of male/female pipe threaded inlet and outlet. The pressure regulator will have a built-in indicator that shows when it is operating.

5. Disc Filter: A multiple disc filter equipped with size 120 mesh and constructed of chemical-resistant thermoplastic for corrosion resistance. The body shall be molded of black plastic with male pipe threads for both inlet and outlet. The disc filter shall be capable of periodic servicing by unscrewing a threaded cap or unlatching the band.

2.09 MASTER VALVES
A. Heavy duty, brass or bronze construction, capable of operation from controller, installed underground with unions, equipped with standard cross handle operating wheel. Normally closed, solenoid actuated globe pattern diaphragm type with valve pressure rating not less than 200 psi.

2.10 UNIONS
A. PVC schedule 80 threaded for below-grade locations, and provided on both sides of the master control valves, irrigation control valves, strainers, backflow prevention assembly, and pressure reducing valves.

2.11 IRRIGATION VALVE BOXES AND VALVE KEYS
A. For irrigation control valves, drip control valve assemblies and gate valves: black plastic valve box with snap lock black cover. Minimum size shall be 16 inches by 12 inches by 10-3/4 inches. Size valve boxes to ensure 3” clearance around and between all connections and valves. Multiple valves may be installed in 1 box, provided that clearances are met.

B. For flow sensor: black plastic valve box with snap lock black cover. Minimum size shall be 16 inches by 12 inches by 10-3/4 inches.

C. For automatic flush valves and air relief valves: Provide a 2 inch diameter, Class 160 PVC protective sleeve with locking cap.


E. Quick coupler valves: as shown on Contract Drawings. Color: black.

F. Provide 1 set of keys required for valves, valve box covers and protective sleeve caps.

2.12 IRRIGATION CONTROLLER
A. Irrigation Controller:
1. Compatible with Maxicom2 irrigation central control systems. Controller shall include Ethernet connectivity to the Building Management System.

2. Capable of rain delay shut off and flow control leak detection.

3. Type: Rain Bird ESP-SAT Series, or accepted equal.

B. Provide controller for complete automatic operation of irrigation system: commercial grade, in weatherproof, lockable box or cabinet, UL listed and with adequate number of stations to operate system. Provide stations with independent time controls with 1 minute incremental settings up to 60 minutes maximum per station. Provide controllers to allow easily made changes on station timing and programs start time without tools or disassembling. Stations may be omitted with time setting of zero minutes. Provide rapid advance between stations and override on each station for manual operation. Provide for schedules up to 1 week and permit multicycle operation as often as every hour. Equip controller with manual start switch for activation of semi-automatic watering cycle.

C. Capable of operating 24-V ac irrigation control valves.

D. Provide a UL listed 24-V ac transformer with controller. Color-code station wiring with irrigation zone indicator key visibly imprinted. Include pump start or master valve control with controller and circuit overload protection to prevent damage due to voltage surges.

E. Controller Housing: Heavy-gauge steel coated with rust inhibitor; finish with industrial gray enamel. Weatherproof cabinet, NEMA Type 4. Gasket controller door and provide covered, heavy-duty lock for protection against theft and vandalism. Mount controller components on face panel for easy removal. Print operating instructions on face of controller for easy access when programming.

F. Lock Cylinder and Master Keying: As specified in Contract Specifications Section 08 71 00, Door Hardware.

2.13 RAIN SENSOR

A. Capable of transmitting signal to irrigation system controller to arrest or delay water schedule due to rain events. Manufacturers: Rain Bird, Hunter, Toro, or accepted equal.

2.14 IRRIGATION CONTROL WIRE

A. Provide thermoplastic insulated, solid copper conductor conforming to ASTM B3, suitable for continuous operation at 24-V ac.

B. Direct burial control wires to irrigation control valves: NEC Type UF or G.E. Co. No. SI-58-51 or accepted equal. Size wire to each irrigation control valve to not exceed 5 percent voltage drop from impressed voltage, not less than No. 14 AWG.

C. Common wire: white insulation. Control wire: 1 color other than white or green. Use a different color control wire for each irrigation control valve.

D. Waterproof wire splice connections: 3M DBY, Rain Bird's Penn-Tite, Scotchlok, or accepted equal.

2.15 WIRE SLEEVE (CONDUIT)

A. Conduit below paving: Schedule 40 PVC sized in accordance with irrigation details, or as required to accommodate the number of control wires at each sleeve.
2.16 BACKFLOW PREVENTER
A. Double Check Valve Assembly with the following:
   1. Internally spring-loaded isolation valves, 2 ball valves, and 4 field test cocks.
   2. All check valve internal parts shall be easily accessible from top of device without removing check valve body from line.
   3. Assembly shall be rated to 175 psi working pressure.
   4. After testing, remove and plug test cocks.
   5. Install washed gravel under assembly to provide adequate drainage.
   6. Backflow preventer size shall be same as pipe or larger.
   7. Febco, Watts, or accepted equal.

2.17 GATE VALVES
A. AWWA C500, bronze body, bronze mounted, non-rising stem with solid wedge gates.
B. Pressure rating: 300 psi.
C. Manufacturer: Wilkins, Nibco, Watts, or accepted equal.

2.18 PRESSURE REDUCING VALVE
A. Brass body, pressure rating 300 psi. Pressure range 25 to 75 psi adjustable. Basis of design: Wilkins 600, or accepted equal.
B. Factory pressure set at 50 psi.

2.19 QUICK COUPLING VALVES
A. Quick coupling valves shall be two-piece body type of heavy duty brass or of heavy duty bronze, and watertight both before and after the coupler is inserted. The valve mechanism shall be designed to ensure that the valve seat is closed before the coupler is removed. Each valve shall have the manufacturer’s identification cast or stamped on the valve.
B. Manufacturer: Rain Bird, Hunter, Toro, or accepted equal.

2.20 FLOW SENSOR
A. Capable of transmitting signal to irrigation controller to indicate abnormal flow or leak.
B. Manufacturer: Rain Bird, Hunter, Data Industrial, or accepted equal.

2.21 WATER METER
A. Refer to Mechanical Drawings.
PART 3 - EXECUTION

3.01 GENERAL

A. Verify static pressure at point of connection before installing irrigation system. Report any discrepancy to Resident Engineer.

B. Unless otherwise indicated, irrigation system shown on plans is schematic. With acceptance of the Resident Engineer, make adjustments where necessary to conform to actual field conditions. Irrigation system must be operational, with uniform and adequate coverage of areas to be irrigated prior to planting.

C. Service connections: As indicated or designated by utility company. Notify the Resident Engineer at least 3 weeks before electrical and water services are required. Furnish labor and materials to connect to service connection.

D. Water Supply: Connect to water supply at locations indicated. Make minor changes caused by actual site conditions.

E. Code Requirements: Before Work of this Section, carefully inspect installed Work of other trades and verify that the Work is complete to the point where irrigation system installation may commence properly. Verify irrigation system can be installed in accordance with pertinent codes and regulations, original design, referenced standards and manufacturer's recommendations.

1. Immediately notify the Resident Engineer of conflicts between equipment or methods indicated or specified with local codes, prior to start of installation. If Contractor fails to give notification, assume responsibility for cost of revisions necessary to comply with code.

F. Grades: Before starting Work, carefully review grades to determine if irrigation Work may proceed. Keep within specified material depths with respect to finish grade.

G. Conduct all irrigation Work within tree protection areas in accordance with 01 56 39, Temporary Tree and Plant Protection.

H. Coordination with Work of other trades. Make necessary measurements in field to ensure precise fit of items in accordance with original design. Coordinate installation of irrigation materials with other Work. Coordinate piping locations with tree and shrub locations to avoid conflicts.

3.02 INSTALLATION

A. Excavating and Backfilling:

1. Perform excavation and backfilling as specified in Section 31 20 00, Earth Moving. Restore existing surfaces to original condition.

2. Provide not less than 12 inch depth of soil cover over lateral pipes, not less than 18 inch depth of soil cover over mainlines.

3. Provide 2 inch depth of soil cover over driplines.

4. Trenching of new mainline and lateral runs shall be straight and without abrupt grade changes.
5. Trenches shall be free from rock, debris or sharp articles, with a minimum depth as shown in the Contract Drawings. Trench width must allow a minimum of 2 inches between parallel pipes. Do not stack pipes. Excavate trench bottoms with uniform slope of 1/2 percent standard minimum grade.

6. Backfill any excess excavation with suitable materials in conformance with Sections 31 20 00, Earth Moving, and 32 90 00, Planting, which is free of rocks, organic material, or other materials that may damage pipe. Thoroughly compact to give full support to pipe. Backfill when pipe is not in an expanded condition due to heat or pressure. Place backfill material in 6 inch lifts and compact each lift. Backfill to ensure no future settlement of the trench. Thoroughly backfill around sprinklers and be especially attentive to the restriction of movement of sprinklers by external force. Repair all trench settlement during the warranty of this Contract. Backfill trenches uniform with the surrounding grade.

7. Backfill irrigation sleeve trenches and mechanically compact in 2 lifts to a dry density equal to 95 percent of adjacent undisturbed soil. Backfill will conform to adjacent grades without dips, sunken areas, humps, or other surface irregularities.

8. If settlement occurs and subsequent adjustments in pipe, valves, sprinkler heads, lawn or planting, or other construction are necessary, the Contractor shall make all required adjustments.

9. Compaction: Use hand-operated, plate-type, vibratory, or other suitable hand tampers in areas not accessible to larger rollers or compactors. Compact initial backfill material surrounding pipes and conduits to 90 percent maximum density. For pipes, conduits, and sleeves under roads or slabs, compact backfill as specified in Section 31 20 00, Earth Moving.

B. PVC Pipe Assembly

1. Handle plastic materials carefully, store under cover and prevent damage to pipe. Provide support beds for full lengths of pipe when transporting and storing pipe. Do not install damaged or dented pipe.

2. Cut PVC pipe square and remove burrs. Clean pipe and fittings using primer and cleaner recommended by PVC pipe manufacturer. Use tinted primer to aid in visual inspection.

3. Apply a thin, even flow coat of slow drying, heavy duty PVC solvent cement to outside of male fitting. Cure joints as recommended by manufacturer and keep pipe and fitting out of service during curing period. Construct watertight joints equal to or greater in strength than pipe. Do not tap pipe and fittings.

4. Wipe off excess solvent cement with a clean rag. Let welded joints cure at least 15 minutes before moving them and at least 24 hours before water is permitted into pipe.

5. Install pipe fittings for sprinkler and quick coupler valve outlets horizontally and facing the exterior of the planting area.

C. Sleeves:

1. Place pipe to be installed under pavement and through site walls in a pipe sleeve that has an inside diameter not less than 2 inches larger than outside diameter of the pipe or the combined outside diameter of pipes installed.
2. Sleeves through building walls shall have watertight seals.

D. Backflow Preventer:
1. Install unit as indicated on Contract Drawings. Verify exact location with the Resident Engineer before installation.

2. The backflow prevention assemblies will be inspected and tested before use in accordance with the applicable portions of the Washington Administrative Code and other applicable regulations as set forth by the Washington State Department of Health and the City of Seattle. No water is to flow through the assembly until testing and inspection is accepted by the Resident Engineer.

3. Inspections and tests shall be completed and the results recorded by a licensed Backflow Assembly Tester (BAT) Operator or by a Contracting Agency Certified Water Works Operator with a CCS-1 or CCS-2 Classification. Document that the devices are in good operating condition prior to flushing and testing of any downstream water pipes.

4. Installations must be according to procedures outlined in the current edition of “Accepted Procedure and Practice in Cross-Connection Control Manual,” published by the Pacific Northwest Section, American Water Works Association.

E. Irrigation Control Valves
1. Before installation of irrigation control valves, thoroughly flush the mainline.

2. Use valve box extensions by same manufacturer to ensure that box extends completely below the bottom of the valve. Install locking cover bolts.

3. Install valve boxes perpendicular to walks and curbs.

4. Stake location of valve boxes for acceptance by Owner’s Representative prior to installation.

F. Sprinklers:
1. Thoroughly flush lateral pipes and swing joints prior to installation of sprinklers.

2. Install sprinklers as shown on Contract Drawings.

3. Install sprinklers flush with finish grade adjacent to walks, and curbs as detailed. Lower heads to grade before completion of maintenance period.

4. Install sprinklers a minimum of 2 inches and a maximum of 4 inches from hard surface edges.

5. Upon completion of installation, adjust sprinklers to properly distribute water flow to all planting areas. Adjust adjustable sprinklers by fully opening sprinkler nozzle farthest from control valve. Open manual adjustment of control valve slightly to obtain a 24 inch high spray at sprinklers noted above. After this condition has been met, adjust other sprinklers in that section for equal height sprays, regulating control valve as required to maintain condition. Adjust control valve to obtain catalog rate pressure for sprinkler installed. Rotate individual heads to keep sprays within areas of planting areas and eliminate overspray onto pavements, walls, site features and the building.
G. Swing Joints: Connect sprinklers to laterals using a swing joint assembly as shown on Contract Drawings.

H. Drip Irrigation:

1. Install all dripline as indicated on Contract Drawings. Use only Teflon tape on all threaded connections. Make adjustments to alignments to accommodate large trees and shrubs. Ensure alignment adjustments do not reduce amount of water supplied to each plant.

2. Install one 6 inch long metal wire staple every 3 linear feet and 2 staples on each change of direction (tee, elbow, or cross).

3. Dripline fittings shall be mated with dripline by pushing the fitting into the tubing while twisting side to side until the tubing abuts to either adjoining tubing or a fitting stop.

4. Cap or plug all openings as soon as pipes have been installed to prevent the entrance of materials that would obstruct the pipe. Leave in place until removal is necessary for completion of installation.

5. Thoroughly flush all water pipes before installing valves and other accessories.

6. Pipe Sleeves:
   a. Place supply header pipes and dripline tubing in PVC Schedule 80 sleeving at least twice the pipe diameter under all paved areas, drives and roads.
   b. Extend sleeves 1 foot minimum beyond edge of curbs and pavement, cap ends and flag.

7. Dripline Valves and Accessories:
   a. Automatic Flushing Valve: Install in valve box with a gravel sump adequate to drain 1 gallon of water.
   b. Air/Vacuum Relief Valve: Install on pipe perpendicular to dripline rows at high point of each zone. Install in valve box with gravel sump.

I. Control Wire:

1. Lay wires connecting controller and irrigation control valves in trenches with a minimum cover of 18 inches.

2. Sleeve wire under pavement in Schedule 40 PVC pipe.

3. Provide continuous wire runs without splices between controller and irrigation control valves. Splice only at control valves or junction box locations.

4. Install 2 spare wires to run from the controller to the furthest ends of each branch of the mainline.

5. Tape control wires together at 5 foot intervals with electrical tape. Tape this bundle to the bottom of the mainline at 10 foot intervals with at least 1 full wrap of duct tape. Tie a loose 24 inch loop in all wiring runs at changes of direction greater than 30 degrees. Untie all loops after all connections have been made.
J. Irrigation Controller:

1. Coordinate electrical service to controller location. For interior installation, wall-mount controllers within vandal-resistant enclosure as indicated on Contract Drawings.

2. Program irrigation system is to operate after plants have been installed, without conflict with other Work.

3.03 INSPECTION

A. Do not cover installed work before the Resident Engineer has inspected installation. Uncover covered work at no additional cost to Sound Transit.

B. At completion of installation, and before planting of shrubs or groundcover, inspect overall coverage of system. Demonstrate the working system.

C. Completely check system within 5 days before Final Inspection and make necessary corrections. Properly align heads and adjust to ensure full coverage. Clear system of foreign materials. Properly adjust valves. Check sprinkler controller valve chart for accuracy.

D. At end of the Landscape Warranty Period, schedule a Final Inspection of the system with the Resident Engineer. If the Warranty Period ends during the freezing season (see 3.05 SYSTEM PROTECTION), schedule the Final Inspection within 10 days of reactivation of the irrigation system.

3.04 TESTING

A. Perform tests in the presence of the Resident Engineer. Give at least 48 hours advance notice of tests.

B. Hydrostatically test sprinkler pipes normally under pressure as follows:

1. Leave all system joints, connections, and other fittings exposed until after completion and acceptance of pressure test. All subsequent breaches of integrity of the mainline shall require re-testing.

2. Mainline: 120 psi static pressure for 1 hour. Test will fail if pressure loss occurs during the test. Ensure means of air release at terminations and bleeding of all trapped air.

3. Lateral pipes: 80 psi for 30 minutes. Lateral test will include all swing joint assemblies with temporary threaded caps on the downstream Marlex fitting. Wrap caps with 3 wraps of Teflon tape. Ensure means of air release at terminations and bleeding of all trapped air. Test will fail if pressure loss is greater than 5 psi during the duration of the test.

4. Test the entire system as a complete unit. Do not test in separate completed segments.

5. Center load pipe with small amount of backfill to prevent arching and movement under pressure. Leave joints exposed for inspection during pressure test. No water is permitted in pipe for pressure testing until at least 24 hours has elapsed for solvent weld setting and curing.

6. Test by capping each outlet, filling pipe with water, and applying pressure with a pump. Measure pressure with a pressure gauge. Maintain specified pressure for
1 hour and determine leakage. Immediately correct leaks, and subject system to same test. No pipe, fitting or joint showing leakage will be accepted. After piping has been tested to the satisfaction of the Resident Engineer, backfill pipe trenches before adjustment and testing of sprinklers and valves.

7. Furnish necessary force pump and other test equipment.

C. Irrigation Controller: Test controller for 7 days just before end of establishment period. Operate system automatically in manner indicated.

D. Do not cover installed Work before the Resident Engineer has inspected installation. Uncover covered Work as directed by the Resident Engineer for testing.

E. Drip irrigation: The Contractor must make a full inspection with the Resident Engineer of all components of the system, including the visual inspection of each emitter under operating conditions. Adjustments, flushing, cleaning of filters, replacements to the system must be made immediately to ensure the proper operation of each emitter. Once drip irrigation is successfully tested, cover the dripline as shown on the Contract Drawings.

3.05 SYSTEM PROTECTION

A. Deactivate and drain (winterize) the system prior to the onset of the freezing season (no later than Nov. 15) and reactivate at the onset of the spring season (no earlier than April 15). Accomplish each as often as required during the construction, acceptance, and warranty period. If construction is completed when the system is not in use, winterize after testing. Certify by letter the dates of each winterization and activation. Repair damage from failure to comply.

B. When using compressed air to winterize the system, do so in short cycles at no more than 40 psi air pressure. Do not allow pipe close to the compressor to get hot to the touch.

3.06 CLEAN UP

A. Upon completion of Work, clean up excess materials, equipment, and rubbish resulting from Work. Leave premises in a clean, neat and orderly condition.

3.07 TRAINING

A. Thirty days prior to completion of the plant Warranty Period, the Contractor shall provide a course on the use, adjustment, and maintenance of the automatic controller and irrigation heads. The instructions shall include an on-Site review/walk through of the irrigation system(s) as well as an office session to review the O&M Manual documentation. If the Warranty Period ends during the freezing season, schedule the training within 10 days of the Final Inspection after reactivation of the irrigation system.

B. Approximately 10 maintenance persons will attend the course. The Contractor shall schedule the course through the Resident Engineer at a time convenient to Sound Transit. The Contractor must notify the Resident Engineer of the proposed course dates at least 6 weeks before those scheduled dates.

3.08 EXHIBITS

1. Roosevelt Station
a. System Description: The planting irrigation for this station consists of 2 completely automatic, electrically controlled spray and drip irrigation systems. A separate system is provided for each station entry: north and south, as shown on the Contract Drawings.

b. Water source: Water is supplied by a rainwater harvest system. Refer to the Mechanical Drawings.

c. Exclusions from Part 2 & 3: This station does not include a pressure reducing valve.

2. Brooklyn Station

a. System Description: The planting irrigation system for this station consists of a completely automatic, electrically controlled spray and drip irrigation system.

b. Water source: Water is supplied from the station potable water supply at an irrigation point of connection in the building. Irrigation water distribution piping is routed through the building to stub-out locations as shown on the Contract Drawings. Controls are also in the building.

c. Exclusions from Parts 2 and 3: This station does not include sprinkler pop-up bodies or swing joints.

3. Northgate Station

a. System Description: The planting irrigation system for this station consists of a completely automatic, electrically controlled spray and drip irrigation system.

b. Water source: Water is supplied by a rainwater harvest system. Refer to the Mechanical Drawings.

END OF SECTION [A6]
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for:
   1. Soil preparation of all planting areas to include discing, amending, incorporation, and mixing to prepare soils.
   2. Testing of prepared planting soils.
   3. Fine grading.
   4. Furnishing, installation, and maintenance of planting.
   5. Staking and guying of trees.
   6. Mulching of planting areas.
   7. Fertilization and maintenance.
   8. Repair and restoration of existing vegetation.
   9. Cleanup.
   10. Warranty of plants.

B. This Section includes a Warranty Period of 1 year duration to ensure the health and resumption of growth of planted materials.

C. Related Sections: The Work of the following Sections is related to the Work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this Work.
   1. Section 01 33 00, Submittal Procedures.
   2. Section 01 56 39, Temporary Tree and Plant Protection.
   3. Section 31 20 00, Earth Moving.
   4. Section 32 84 00, Planting Irrigation.

1.02 REFERENCES

A. This Section incorporates by reference the latest version of the following documents.
   1. American Association of Nurseymen (AAN):
   2. American Joint Committee on Horticultural Nomenclature:
a. Standardized Plant Names (SPN).

1.03 DEFINITIONS

A. Soils:

1. Topsoil: Imported soil used as a component of prepared planting soil for non-rain garden planting areas, conforming to the product description in this Section.

2. Prepared Planting Soil: Mixture of native soil and topsoil as described in this Section.

3. Rain Garden Soil: Imported soil for rain garden areas, conforming to the product description in this Section.


5. Planting Backfill: Mixture of native soil and topsoil for tree and shrub planting pits that exceed the prepared planting soil depth for the planting areas.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Source of Supply Plan.

1. Submit plan for the procurement of plant material within 60 days of project notice to proceed. Include:
   a. Plant List.
   b. Documentation that plants are being contract grown or deposits have been provided to nurseries to insure availability for all plants on the Plant Schedule.
   c. Name and contact information of growers.
   d. Representative photographs of supplier’s stock.

2. Should at any time the nursery stock be lost or compromised due to weather or other natural occurrences, notify the Resident Engineer immediately of the need to locate new material.

C. Product Data: Submit at least one month prior to landscape preconstruction meeting product literature or tear sheets giving name of product, manufacturer’s name, and compliance with Specifications AMS3, LC4, A5.

1. Commercial fertilizer.

2. Anti-desiccant.

3. Mycorrhizae.

D. Samples: Submit at least one month prior to landscape preconstruction meeting.

1. Organic Mulch: One pound bag.

2. Guying Material: One 12 inch length.
3. Organic Amendment: One pound bag.
4. Topsoil: One pound bag.
5. Rain Garden Soil: One pound bag.

E. Certifications / Shop Construction Documents: Submit at least one month prior to landscape preconstruction meeting with certificate names of materials and manufacturer.
1. Commercial Fertilizers: Include guaranteed analyses.
2. Plant Material: Furnish certificates of inspection as may be required by Federal, State or other authorities that plant material is free of disease or hazardous insects.
3. Ground Dolomitic Limestone: Include guaranteed analysis and weight of packaged material.
4. Organic Amendment: Include acid reaction, content of woody material, water absorbing capacity and moisture content by weight.

F. Delivery, Storage, and Handling Plan.
1. Submit at least one week prior to the landscape preconstruction meeting.
2. Indicate:
   a. Proposed location for on-site plant holding.
   b. Water source.
   c. Protection measures proposed for various seasonal conditions.

G. Schedule and Work Plan.
1. Submit at least one week prior to landscape preconstruction meeting the proposed planting schedule.
   a. Indicate:
      1) Name and phone number of the forepersons
      2) Dates for each type of landscape work. Conduct planting during normal seasons for such work in the geographic region.
      3) Substantial Completion date.
2. Once accepted, if there are delays, revise and resubmit the Schedule for acceptance, and include documentation of reasons for delays and the revised dates.

H. Test Reports
1. Schedule testing such that it does not interfere with the construction schedule. Test report submittals for all areas must be accepted prior to any planting.
2. Submittal for Prepared Planting Soil:
a. Employ an approved agricultural testing laboratory to perform soil testing. The soil testing laboratory must be accepted by the Resident Engineer in advance. The testing lab must be a member of the Soil Science Society of America’s, North American Proficiency Testing Program (NAPT).

b. Test prepared planting soil in three locations, including one sample tree planting pit, as selected by the Resident Engineer. Follow soil testing lab’s instructions for soil sample collection.

c. The test shall provide the following: pH and Buffer pH; percent organic content by oven dried weight; nutrient levels by parts per million including nitrogen, phosphorus, potassium magnesium, manganese, iron, zinc and calcium; soluble salt by electrical conductivity of a 1:2 soil water sample measured in milliohm per centimeter; and the Cation Exchange Capacity (CEC).

d. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the prepared planting soil. Chemical analysis shall include recommendations from the soils laboratory as to ranges of each chemical element appropriate for the types of plants to be grown in the prepared planting soil.

e. If soil does not meet criteria established by the agricultural chemist for growth of healthy plantings, submit a program of additional amendments based on recommendations of the agricultural chemist.

3. Tree Pit Drainage Test Report

a. Submit a report on the drainage of standing water in all tree pits. Include amount of time required for each tree pit to completely drain after each tree pit is filled with water.

I. Photographs of Plants: Submit representative photograph of each plant species being held 60 days prior to planting, or 30 days prior to final digging deadline for the planting season (whichever is sooner).

J. Plant Substitutions: Plant substitutions will not be permitted unless the Contractor furnishes the Resident Engineer with written evidence from no less than three nurseries that the plants specified are not obtainable.

K. Written request in advance for the following inspections:

1. Substantial Completion
2. Final Inspection

1.05 MEETINGS AND INSPECTIONS

A. Preconstruction Meeting: Arrange a preconstruction meeting between the Resident Engineer, Landscape Architect, Contractor, and Planting and Irrigation Subcontractor(s) to review the proposed landscape schedule, source of plants, consideration of substitutions, review of specifications, and planting and irrigation procedures.

B. Inspections: Inspection of Plant Material: As specified in this Section.

C. Inspection for Substantial Completion: As specified in this Section.
D. Inspection for Final Acceptance: As specified in this Section.

1.06 QUALITY ASSURANCE

A. Landscape Contractor: Must be a firm licensed in the State of Washington with at least 5 years of experience on projects of similar scope, and experienced in landscape work of the highest professional quality. Firm must have equipment and personnel adequate to perform the Work specified.

B. Underground Utilities: Protected. Repair any damage to original condition.

C. Protection: For all work in progress. Protect adjoining property, and be responsible for protection from bodily injury due to construction operations.

D. Restoration of Existing Vegetation in Areas to Remain: Restore areas damaged during construction as approved by Resident Engineer. Restore all lawn, planting, trees and irrigation in surrounding areas damaged during construction according to accepted horticultural practice and in compliance with this Section as well as Section 01 56 39, Temporary Tree and Plant Protection, and Section 32 84 00, Planting Irrigation.

E. Permits, Codes and Regulations: Assure all work is in compliance with all applicable codes, regulations, and all related documents including but not limited to:

1. Seattle Land Use and Zoning Code
2. Seattle Department of Transportation
3. International Building Code

F. Quality of Work: Equal to best accepted trade practices.

G. Settlement Test: Install 20 square feet of prepared planting soil and rain garden soil at specified depth and apply irrigation to induce settlement to determine percent of additional soil required to achieve specified grade conditions of soil after settling. Supplement specified depth of soil in all plant beds with additional topsoil as needed to achieve specified grade conditions.

1.07 REGULATORY REQUIREMENTS

A. Investigate the conditions of public thoroughfares and roads as to availability, clearances, loads, limits, restrictions, and other limitations affecting transportation to, ingress, and egress at the site. Ship landscape materials with certificates of inspection required by governing authorities. Conform to all governmental regulations regarding the transportation of materials.

1.08 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01 66 00 Product Storage and Handling Requirements.

B. Delivery:

1. Delivery fertilizer and plant treatment materials to the site in original unopened containers bearing manufacturer’s guaranteed chemical analysis, weight, manufacturer’s name, trademark, and conformance with state law.

2. Label trees, shrubs, and groundcovers. State correct plant name and size as indicated on the plant list on the Contract Drawings.
3. Do not prune plants prior to delivery.

4. Prevent injury and windburns on trees during transportation. Provide protective covering for plants during delivery. Provide adequate protection so that trunks are not scarred in transport and branches are not broken.

5. Notify the Resident Engineer in advance of delivery of plant materials and submit an itemized list of the plants in each delivery.

C. Plant selection and inspection:

1. Tagging Plant Material: Attach legible labels to each individual plant or container containing one or more plants. Labels must give the necessary detailed information as to horticultural name, size, or other data required to identify as conforming to specifications. When the label is attached to a container containing more than one plant, information on the label must show the quantity together with other required information. Refer to Nursery Stock Standards regarding labeling of plant material. The Resident Engineer will reject plant material with illegible or missing tags.

2. Inspection of Plant Material: Provide the Resident Engineer an opportunity to inspect plant material at nursery or offsite holding area prior to arrival on site. All plant materials will be inspected by Resident Engineer after arrival on site. Notify the Resident Engineer four business days prior to the proposed arrival of plant materials on site. Arrange for adequate manpower and equipment on site at the time of plant material inspection to unload, open, and handle plant material during inspection. Immediately remove plants not meeting the requirements herein specified or matching approved representative photographs, and replace.

3. Plant layout inspection: Provide the Resident Engineer an opportunity to inspect plant layout in accordance with Contract Documents prior to installation.

D. General Temporary Storage:

1. If planting is delayed more than 24 hours after delivery, set balled and burlapped plants on the ground well protected with soil, wet peat, or other acceptable material. Adequately cover all roots of bare root material with soil, wet peat, or other means of retaining moisture as accepted by the Resident Engineer. Protect balls and roots and container grown material from freezing, sun, drying winds, and/or mechanical damage.

2. Water as necessary until planted. Immediately install plant material delivered and accepted.

3. Plants stored under temporary conditions accepted by the Resident Engineer are the sole responsibility of the Contractor.

4. Do not heel in plants for more than one week. Provide temporary storage in accordance with the accepted Delivery, Storage, and Handling Plan Submittal.

5. Plants temporarily stored are subject to inspection and acceptance prior to planting.

6. Immediately remove rejected plant material from the site.

7. Do not remove container-grown stock from containers until planting time.
E. Handling:

1. Exercise care in handling, loading, unloading and storing of plant materials. Plant materials damaged in any way shall be discarded and replaced with undamaged materials.

2. Protect packaged materials from deterioration during storage. Fertilizer and plant treatment materials shall not be stored with any other landscape material.

1.09 PROJECT CONDITIONS

A. Environmental Requirements:

1. Work soil only during suitable weather conditions. Do not disc, rototill, or work soil when ground is frozen, excessively wet, or in otherwise unsatisfactory condition.

2. Do not plant when the ground is frozen, or the soil is otherwise in an unsatisfactory condition for planting.

3. Do not plant during periods of excessive heat, drought, moisture and cold.

B. Existing Conditions:

1. Carefully examine the site before submitting a Bid. Be informed as to the nature and location of the Work, general and local conditions including climate, adjacent properties and utilities, confirmation of the ground, the nature of subsurface conditions, and the character of equipment and facilities needed prior to and during execution of the Work.

2. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify the Resident Engineer before planting.

3. Proceed with and complete landscape work as rapidly as portions of the site become available, working within seasonal limitations for each kind of landscape work required.

4. Utilities: Determine location of underground utilities and perform work in a manner that will avoid possible damage. Hand excavate, as required. Maintain grade stakes set by others until concerned parties mutually agree upon removal.

5. Should the Contractor, in the course of work, find any discrepancies between Drawings and physical conditions or any omissions or errors in Drawings, or in layout as furnished by the Resident Engineer, it will be their duty to inform the Resident Engineer immediately in writing for clarification. Work done after such discovery, unless authorized by the Resident Engineer, is at the Contractor's risk.

1.10 SEQUENCING AND SCHEDULING

A. Coordinate Work of this Section with other Work.

B. Planting Time: Install plants in the planting season beginning October 1 through April 30, unless otherwise approved by the Resident Engineer.

C. Coordinate earthwork and soil preparation. Do not expose soil stockpiles for longer than 15 days without temporary or permanent vegetative, or other, cover. Test any soil stockpiles exposed longer than 15 days in accordance with testing requirements.
D. Landscape work shall not begin until structures, utilities, paving, and other improvements which require access to, or through, planting areas have been installed and accepted by the Resident Engineer.

E. Install trees prior to irrigation installation per Section 32 84 00 Planting Irrigation. All other planting work shall not begin until the landscape irrigation system is installed in place, tested, and accepted by the Resident Engineer.

1.11 SUBSTANTIAL COMPLETION

A. The Resident Engineer will make an inspection for Substantial Completion of the work of this Section. Furnish a full and complete written program for maintenance of the planting during the Warranty Period for review by the Resident Engineer at the time of the request for Substantial Completion.

B. Submit a written request for inspection at least four days prior to the day on which the inspection is requested.

C. All planting shall be alive, healthy, and installed as specified to be accepted.

D. Upon completion of planting, and prior to receipt of certificate of Substantial Completion, remove from site excess soil and debris and repair all damage resulting from planting operations.

E. The Contractor is to prepare a list of items to be completed or corrected for review by the Resident Engineer.

F. Upon completion of the inspection, the Resident Engineer will amend the list of items to be completed or corrected, and indicate the time period for their completion or correction.

G. The Warranty Period will not begin until all items have been completed or corrected.

1.12 WARRANTY PERIOD

A. General: The Contract shall provide adequate and proper care for plant materials and landscape areas within the Contract limits during the Warranty Period to ensure the health and resumption of growth of the plant materials. The Warranty Period begins after the date of the Substantial Completion and ends one year thereafter. Substantial Completion will be certified in writing by the Resident Engineer.

B. Make warranties in addition to and not in lieu of all other liabilities, which manufacturers or Contractor may have by law or by other provisions of the Contract Documents.

C. The Contractor is responsible for maintenance of all plant materials from construction through the end of the Warranty Period. It is the Contractor's responsibility to regularly inspect the plant materials to satisfy themselves that the areas are receiving proper care.

D. Warranty for Plants:

1. Replace at no additional cost for a period of one year after the establishment of the beginning date of Warranty Period, plants that have died or that are, in the opinion of the Resident Engineer, in unhealthy or unsightly condition, or that have lost their natural shape due to dead branches, excessive pruning, or excessive defoliation. Make replacement within seven days of notification from the Resident Engineer. Remove dead plants within two days of notification and mark planting plan showing the exact location of replaced plants.
2. Replace unacceptable plants in accordance with original Specification. Warranty all replaced material for a period of one year from date of replacement, or 30 days after Final Inspection, whichever comes first.

3. Warranty plants for one year against all defects of material and workmanship.

4. Any tree and shrub material that is 25 percent or more dead or disfigured shall be considered dead and must be replaced at no charge. A tree is considered dead when the main leader has died back or there is 25 percent of the crown dead. Plants are considered disfigured when excessive dead wood had been removed or when the symmetry, typical habit of growth, or sculptured form has been impaired by the removal of dead wood.

5. The above warranty is applicable to any growing conditions through which plants of like kind could be expected to survive and any deformity or cause of death which could be attributed to, or affected by, the physiological conditions of the plant. The warranty would not apply to plant losses due to abnormal weather conditions such as floods, excessive wind damage, drought, severe freezing, or abnormal rain, as determined by the National Weather Service.

E. Maintenance shall begin immediately after each plant is planted. Plants shall be watered, mulched, weeded, pruned, sprayed, fertilized, cultivated, and otherwise maintained and protected until the end of the Warranty Period. Tree ties and stakes shall be tightened and repaired as required. Correct defective work as soon as possible after it becomes apparent and weather and season permit. Reset settled plants to proper grade and position, and remove dead material.

F. Watering: Water plants as needed to keep them in a healthy growing condition. The contractor shall be responsible for the watering patterns and timing, including the setting of automatic sprinkler controls. Automatic irrigation systems shall be operated fully automatically during the Warranty Period. Perform automatic watering during the periods of 4 a.m. to 7 a.m. or as otherwise specified. If water restrictions are established, develop watering schedules in consultation with the Resident Engineer. The Contractor is responsible for acquiring a water source for any hand-watering. Before commencement of the Warranty Period, furnish in writing a watering schedule to the Resident Engineer. The Contractor shall maintain and operate the irrigation system components installed as part of the Work shall be maintained and operated by the Contractor as part of the Warranty Period.

G. Warranty Period also includes maintenance of the planting irrigation system as described in Section 32 84 00, Planting Irrigation.

H. Mulch: Mulch material shall be applied and replaced in order to return planting areas to conformance with Contract Document when ordered by the Resident Engineer. The final mulch application shall be made 1 week before inspection for acceptance.

I. Cleanup and Litter Removal: A general cleanup shall be made after any work performed by the Contractor during the Warranty Period. Unless otherwise specified in the Contract, remove all litter in order to provide a clean appearance at the time of Warranty Period inspections.

J. Weed Control: Maintain mulched planting areas around trees, shrubs, and groundcovers in a weed-free condition during initial planting and during the Warranty Period. At least 5 working days before the beginning of the Warranty Period, submit a weed control plan identifying the means, manner, methods, and timing intervals to ensure weed control.
This weed control plan will be subject to revisions dependent on results of the implemented plan.

K. Inspections: Planting areas will be inspected regularly by the Resident Engineer during the Warranty Period. Should the Resident Engineer determine at any time that the Contractor is not providing adequate and proper care of plant material or is performing substandard Warranty Period work, the Resident Engineer will order the Contractor in writing to correct and remedy such unsatisfactory work. The Contractor shall make the necessary correction within a 5 day period immediately following receipt of such notice. In addition to periodic unscheduled inspections of the Work, four quarterly inspections will be scheduled to review the conditions of the site during the Warranty Period.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Soil Amendment Materials:

1. Organic Amendments:

   a. Composted material must be in compliance with WA Department of Ecology’s specifications, which appear in WAC Chapter 173-350 Section 220; plus the following additional requirements.

   b. Additional requirements:

      1) The carbon to nitrogen ratio of the compost shall be below 25:1 or below 35:1 if the proposed plantings are composed entirely of plants native to the Puget Sound Lowlands region.

      2) The compost shall have an organic matter content of 35% to 65% as determined by “loss on ignition” test method [A17].

B. Topsoil: 3-way topsoil composed as 60 percent sandy loam, 25-30 percent organic amendment and 10-15 percent peat with 100 percent passing through a 1/2 inch screen as supplied by Pacific Topsoils, Inc. (425) 514-3499, Cedar Grove (877) 764-5748, Sawdust Supply Co. (888) 622-4321, or accepted equal.

C. Rain Garden Soil: Provide Landscape Bioretention soil type 1 in accordance with City of Seattle Standard Specification 7-21 Bioretention Soil for Turf and Landscape Areas, as noted in Section 9-14.1(3)B. Where section 9-14.1(3)B refers to Section 9-03.2(2) for drainage aggregate modify requirements to the following:

   1. Mineral aggregate for Turf and Landscape Bioretention Soils shall be analyzed by an accredited lab using No. 200, No. 100, No. 60, No. 40 and No. 20, No. 10, No. 4, 3/8 inch, and 1 inch sieves, and meet the following gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
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<tbody>
<tr>
<td>3/8&quot;</td>
<td>100</td>
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<tr>
<td>No. 4</td>
<td>95 - 100</td>
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<tr>
<td>No. 10</td>
<td>75 - 90</td>
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<td>No. 40</td>
<td>25 - 40</td>
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<tr>
<td>No. 100</td>
<td>4 - 10</td>
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<tr>
<td>No. 200</td>
<td>2 - 5</td>
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</tbody>
</table>
Efforts should be made to have the mineral aggregate for Turf and Landscape Bioretention Soils meet the following gradation coefficients: Coefficient of Uniformity ($C_u = D_{60}/D_{10}$) equal to or greater than 6; and Coefficient of Curve ($C_c = D_{30}/D_{60}D_{10}$) greater than or equal to 1 and less than or equal to 3.

D. Sand: Natural, medium to coarse grained in texture, free from salt and decomposed organic matter such as roots, sticks, leaves, paper, and of any other undesirable trash such as glass, plastic, or metal fragments that could interfere with soil drainage and planting operations.

E. Dolomitic Limestone: Fine ground dolomite with minimum of 88 percent of No. 20 sieve retaining 0 percent and No. 100 sieve retaining 25 percent, and packaged in new, waterproof, non-overlain bags, clearly labeled.

F. Water: Potable, clean, fresh, and free from harmful materials. Furnish all hoses and other irrigation equipment required for the Work.

G. Plants:

1. Trees and Shrubs:
   a. Provide freshly dug trees and shrubs that are nursery grown in accordance with good horticultural practice for at least two years under climatic conditions and soils similar to those at job site.
      1) Trees: Straight trunks with leader intact, undamaged, and uncut.
   b. Appearance to be typical of species or variety with normal growth habit, in accordance with ASNS.
      1) Sound, healthy and vigorous; well-branched and densely foliated when in leaf with healthy root systems, free from disease, insect pests, eggs or larvae, disfiguring knots, sun-scalds, abrasions of the bark, broken tops, torn roots, and any other objectionable feature.
      2) Nomenclature: Agree with SPN as accepted in the nursery trade for varieties not listed therein. Clonal types shall be true.
      3) Measure height or spread and quality in accordance with standards specified in ASNS (unless otherwise specified).
   c. Conform to measurements specified on Plant Schedule. Dimension plants in their natural position. Plants larger than specified may be used, without increasing Contract Price, if accepted by the Resident Engineer. Large plants cut back to sizes specified will not be accepted.
   d. Provide balled and burlapped stock (B&B) with a compact natural ball of earth firmly wrapped and tied in burlap so that upon delivery the soil in the ball is still firm and compact about the small feeding roots. Root ball sizes shall be in accordance with standards specified in ASNS.
   e. Provide container grown stock that is healthy, vigorous, and well-rooted. Plants grown in a container shall have a well-established root system reaching the sides of container and maintain a firm ball when removed from the container. The container shall be rigid enough to hold the ball
shape and protect root mass during shipping, and be sized according to ANSI Z60.1 for type and size of plant required.

2. Groundcover: Furnish in sizes indicated on the Contract Drawings and conform to ASNS standards for species and size.

H. Staking and Guying:


2. Tree Ties: Recycled polyethylene, Dimex ProLock Poly Chain Lock, or accepted equal.

3. Twine: 3-ply jute.

I. Mulch:

1. Organic Mulch: Fine fir or hemlock bark of uniform color for use in planting or tree and shrub saucers free from weed seed, sawdust and splinters; not containing resin, tannin, wood fiber or other compounds detrimental to plant life.
   
   a. Bagged mulch: Moisture content not in excess of 22 percent.
   
   b. Bulk mulch: Size range of 1/2 inch to 1-1/4 inch with a maximum of 20 percent passing a 1/2 inch screen.

2. Crushed Rock Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color detrimental to plant life.
   
   a. Type: crushed granite.
   
   b. Size: 3/8 minus.
   
   c. Color: grey.

J. Fertilizers:

1. General: Packaged in new, waterproof, non-overlaid 80 pound bags clearly labeled as to weight.

2. Fertilizer to be commercial grade, containing not less than 10 percent Nitrogen, 6 percent phosphorous and 4 percent potash by weight of ingredients.

K. Plant Treatment Materials:

1. Pesticides (Herbicides, Insecticides, Fungicides, etc.): must be in accordance with regulations by local, State, and federal agencies, the type of treatment and rate of application. Submit treatment plan with product material safety data sheets to the Resident Engineer for review and acceptance prior to application.

2. Anti-desiccant: Wiltpruf as manufactured by Wiltpruf Products, Inc., PO Box 4280, Greenwich, CT 06830, (203) 531-4740; Moisturin as manufactured by GSI Horticultural, 141 NW Greenwood, St. 200, Bend, OR 97701, (541) 383-0222 (www.gsihorticultural.com); or Vapor Guard as manufactured by Miller Chemical & Fertilizer Corp., PO Box 333, Hanover, PA 17331, (717) 632-8921 (www.millerchemical.com), or accepted equal.
3. Mycorrhizae: MycoGrow Gel as manufactured by Fungi Perfecti, Olympia, WA, (800) 780-9126; Mycorrhizal Landscape Inoculant as manufactured by BioOrganics, Santa Monica, CA, 1-888-332-7676; or Biovam as manufactured by Brock Probiotics and available through T&J Enterprises, Spokane, WA (509) 327-7670, or accepted equal.

2.02 SOURCE QUALITY CONTROL

A. Plant Material: Provide plants of quantity, size, genus, species, and variety as indicated in the Construction Documents for landscaping work and complying with recommendations and requirements of ASNS. Provide healthy, vigorous stock, grown in recognized nurseries in accordance with horticultural practice and free of disease, insects, eggs, larva, and defects such as knots, sun-scald, injuries, abrasions, or disfigurement.

B. Plant List: In accordance with submitted Source of Supply Plan.

C. Substitutions: Substitutions will not be permitted unless substantiated written proof is supplied that a specified plant is not obtainable. In this situation, submit for acceptance by the Resident Engineer a proposal to use the nearest equivalent size or variety with an equitable adjustment of the Contract shall be submitted.

D. Contractor: Perform work with personnel familiar with planting techniques under the supervision of experienced landscape forepersons at all times.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to preparation of planting areas, ascertain the location of all electric cables, conduits, underdrainage systems and utility lines. Take proper precautions to not disturb or damage sub-surface elements. If sub-surface elements are uncovered, promptly notify the Resident Engineer. Contractor is responsible for making requisite repairs to damaged utilities at his own expense if this procedure is not followed.

1. Verify that required underground utilities are available, in proper location, and ready for use. Coordinate with other trades.

2. Verify that subgrades are at lines and grades appropriate to provide specified depth of prepared planting soil.

3.02 PREPARATION

A. Protection of Existing Conditions:

1. Use every possible precaution to prevent damage to existing conditions to remain, such as structures, utilities, plant materials, and walks on, or adjacent to, the site of the Work.

2. Provide barricades, fences, or other barriers to protect existing conditions to remain from damage during construction.

3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.

4. Submit written notification of damaged plants and structures to the Resident Engineer immediately.
B. Preparation of Planting Areas:

1. Subgrade Preparation:
   a. Completely remove and dispose of all engineered structural fill, gravel, quarry spall, constructions debris, and other deleterious material or obstructions in the area to receive planting to a minimum depth of 24 inches, including areas where native soils have been removed and replaced with structural materials adjacent to buildings and paved areas. Remove debris and rocks over 4 inches in size to a depth of at least 24 inches in all areas to receive planting.
   b. Protect and maintain the integrity of the compacted base and subgrade materials under pavements and curbs, and protect all other structures in areas of the soil preparation and/or excavation.
   c. If native soil in areas to receive planting is free from engineered structural fill, gravel, quarry spall, construction debris, and other deleterious materials, establish subgrade lines and grades appropriate to provide for specified depth of prepared planting soil.
   d. If subgrades need to be raised to establish lines and grades appropriate to provide for specified depth of prepared planting soil, use accepted Non-engineered Fill as defined in Section 31 20 00, Earth Moving.
   e. After subgrade lines and grades are established, scarify exposed soils to a depth of at least 24 inches. Moisture condition if necessary. Compact to 85 percent maximum of dry weight density.
   f. Finish subgrades will be inspected and must be accepted by Resident Engineer before installation of soil.

2. Soils in Planting Areas:
   a. Perform Settlement Test for prepared planting soil as specified in Article 1.06G of the Section.
   b. In planting areas on native soil: Provide 12 inches of topsoil in two 6 inch lifts. Place first lift and rototill into top 12 inches of native soil. Place second lift and rototill into top 12 inches of soil.
   c. In planting areas on fill: Provide 18 inches of topsoil in three 6 inch lifts. Place first lift and rototill into top 6 inches of scarified fill. Place second lift and rototill into top 12 inches of soil and fill. Place third lift and rototill into top 12 inches of soil.
   d. In areas that are protected by vegetation protection fencing or are beneath the canopies of existing trees and shrubs, whichever area is greater, perform soil preparation under the direction of the Resident Engineer and the Project Arborist. Loosen native soil by hand using a shovel or fork to avoid loosening or damaging the root systems of existing trees and shrubs. Spread a 2-inch layer of topsoil over native soil. Incorporate topsoil into native soil using a shovel or fork. Feather prepared planting soil grades into adjacent grades outside existing tree and plant canopies.
e. In areas where dense clay native soil material is encountered, spread a two inch layer of sand over the native soil and rototill into the top 12 inches of native soil prior to installation of topsoil.

f. Ensure prepared planting soil is free of stones, clods of earth larger than one inch in diameter and other deleterious matter.

g. Apply soil additives to all planting areas as required to obtain a pH range of 6.0 to 6.5 (Exception: Do not apply lime to ericaceous planting areas.) Do not apply more than 60 pounds of lime per 1,000 square feet at one time. Verify pH by test of each major planting area.

h. Roll or hand compact prepared planting soil to achieve compaction of 85 percent of dry weight density.

i. Test prepared planting soil as specified in Article 1.04H of this Section.

j. Mix additional amendments into the soil as recommended by the testing laboratory as specified in Article 1.04H of this Section, and as accepted by the Resident Engineer.

k. Incorporate amendments thoroughly into the native soil to assure uniform distribution.

3. Rain Garden Soil: Install in accordance with City of Seattle Standard Specification 7-21 Bioretention Soil for Turf and Landscape Areas, as noted in Section 7-21.3(2).

4. Obstructions Below Grade: In the event that roots, rocks, underground construction work, utilities, or obstructions are encountered during discing and tilling operations under this Contract, continue mixing by hand with shovel or fork.

C. Finish Grading:

1. After natural settlement and light rolling, complete work to conform strictly to the lines, grades and elevations indicated. Elevations and landform configuration is critical to project design intent. Supply additional soil as needed to give the specified depths and grade.

2. Grades in planting areas not otherwise indicated shall have uniform levels or slopes between points established by pavements, curbs, catch basins or other utility lids. Finish grade shall be smooth, even and on a uniform plane with no abrupt change in surface, and have no erosion scars.

3. Slope all planting areas to drain. If drainage conditions are questionable, request inspection and direction from the Resident Engineer. Adjustments to accommodate drainage concerns must be approved by the Resident Engineer. Drainage problems discovered after plant material is installed shall be corrected to the satisfaction of the Resident Engineer as part of the Contract.

4. Ensure finish grading accounts for depth of mulch in relation to adjacent grade conditions.

5. Protect all planting areas against compaction by construction equipment.

D. Planting Layout:
1. Stake out new planting where shown on the Contract Drawings except where obstructions exist below ground, overhead, or where changes have been made during construction. Staking shall be accepted by the Resident Engineer. Complete layout of planting beds, plants and pits before seeking acceptance by the Resident Engineer.

2. Coordinate layout and timing of installation of plant material with installation of the irrigation system per 32 84 00 Planting Irrigation to ensure that there will be complete and full irrigation coverage of the planting areas.

E. Planting Backfill:

1. Where planting pits exceed the depth of prepared planting soil, mix 50 percent native topsoil dug from planting pit with 50 percent topsoil as shown in Contract Drawings.

3.03 PLANTING INSTALLATION OF TREES, SHRUBS, AND GROUNDCOVERS

A. Excavation:

1. Excavate all plant pits in accordance with the Contract Drawings after acceptance of staked locations by the Resident Engineer. Excavate plant pits only after prepared planting soil has been tested, analyzed, amended, and accepted by the Resident Engineer.

2. Excavate pits and beds with sloping sides and with the pit bottom's center raised for holding root ball. Loosen sides and bottoms by scarifying.

3. Excavate pits and beds within branch spread of existing trees and shrubs by hand. Notify Resident Engineer immediately if dense root mats or structural or feeder roots are encountered. Resident Engineer will make adjustments to planting locations if new planting excavation will potentially adversely impact existing plant material.

4. Fill tree pits with water prior to planting to test drainage. Submit a Tree Pit Drainage Test Report to the Resident Engineer. Resident Engineer shall inspect and accept plant pits prior to planting. If Resident Engineer determines that drainage is not satisfactory to healthy plant growth, additional excavation and drainage efforts must be made at direction of Resident Engineer.

5. Underground Obstructions: In the event that rock, underground construction work, utilities, or obstructions are encountered in any plant pit excavation work under this Contract, alternate locations may be selected by the Resident Engineer.

6. Where locations cannot be changed, remove obstruction subject to the Resident Engineer acceptance, to a depth of not less than three feet below grade and no less than six inches below bottom of ball or roots when plant is properly set at the required grade. Payment shall be made in accordance with the Contract.

B. Inoculation:

1. Inoculate balled and burlapped plants and container plants with mycorrhizae in accordance with manufacturer’s recommendations.

C. Placement of Plants:
1. Set plants in centers of pits plumb and straight, in accordance with the Contract Drawings, unless otherwise noted in the Contract Documents, and faced to give best appearance and relationship to adjacent plants and structures.

2. Do not plant until the Resident Engineer at site has reviewed and accepted plant material on site.

3. Check top of tree and shrub root ball for root flare. If roots are not found, the Contractor shall scrape away excess root ball soil until root flare is exposed.

4. Plant to such depth that the finished grade level of the plant, after settlement, will be the same as that at which the plant was grown and indicated by the root flare.

5. Do not pull burlap out from under balls, but peel back 2/3 of burlap covering, cut along base, and remove. If root ball wrap is non-biodegradable, remove completely. Remove platforms, wire, and surplus binding from top and sides of ball. Cleanly cut off all broken or frayed roots. Tease out existing roots on perimeter of root ball without disturbing structure of root ball. Cut all girdling roots.

6. Clip and remove wire basket from top and sides of root ball.

7. Remove plants from containers by cutting or inverting the container.

8. Backfilling:
   a. Do not backfill plant pits until the Resident Engineer has accepted them.
   b. Compact planting backfill around bases of root balls to fill all voids. Remove all non-biodegradable materials from the plant pit.
   c. Install planting backfill in layers of not more than six inches. Thoroughly compact by hand to ensure planting backfill is free of voids before next layer is installed.
   d. Where plant pits exceed the depth of prepared planting soil, mix 50% native topsoil dug from the planting pit with 50% topsoil, as shown in the Contract Drawings.
   e. Water thoroughly until the root ball and planting pit is saturated.

D. Mulching:
   1. Do not mulch until soil testing and prescribed soil measures indicated in the testing results have been successfully implemented.
   2. Furnish all equipment and labor to load, haul, and place mulch. Mulch within two days of planting. Cover tree and shrub beds with a continuous three inch layer of mulch. Keep mulch three inches away from tree and shrub root flare.

3.04 REPAIR AND RESTORATION

A. Pruning:
   1. Do not prune plants without acceptance of the Resident Engineer.
   2. Remove dead or broken branches with a clean cut, in a manner appropriate to the particular requirements of each plant, and at the time designated by, and to
the satisfaction of, the Resident Engineer. Perform pruning with clean, sharp tools.

3. Promptly trace and treat accidental damage to trees and shrubs occurring during the course of planting operations which is not so great as to require removal of a branch or the replacement of the plant in accordance with recognized horticultural practices as directed by the Resident Engineer.

B. Watering: Upon completion of planting operation, water plant material thoroughly. Apply water slowly to penetrate and saturate the entire root system while avoiding runoff.

C. Restoration of existing vegetation: Restore native soil, plant material and mulch to a condition equal to that at the commencement of construction, as indicated herein.

3.05 PROTECTION

A. Guying and Staking:

1. Stake or guy trees to stand plumb as detailed immediately after planting. Remove and replace damaged stakes. Any tree or shrub thrown out of plumb by wind or other causes shall be replanted by loosening the soil around the root system and righting the tree or shrub by adjusting the position of the root system. Adjustment shall not be made by pushing or restraining the trunk or stem. If, in the opinion of the Resident Engineer, damage to the root system has occurred as a result of righting a tree or shrub, the tree or shrub shall be replaced by the Contractor.

B. Plant Protection Fence:

1. Prior to installation, stake location of fence as accepted by Resident Engineer. Coordinate location of fence with planting Work so that planting will not be damaged by installation of fence. Install posts plumb and tie taut. Coordinate removal of fence with Resident Engineer.

3.06 ADJUSTING AND CLEANING

A. Maintain the site in an orderly condition during the progress of Work. Continuously and promptly remove excess and waste materials; keep lawn areas, walks, and roads clear. Store materials and equipment where directed. Immediately remove rejected materials from the site. Promptly remove equipment, surplus material, and debris and trash resulting from operations under this Contract upon completion and prior to initial acceptance of Work. Broom clean and leave the site in a neat, orderly condition.

B. Protect landscape work and materials from damage due to landscape operations, operations by other contractors, trades, and trespassers. Maintain protection during installation and maintenance periods. Provide adequate and proper care of all plant material and work done on this project until the contract is completed and accepted by the Resident Engineer. Adequate and proper care means keeping all plant material in a healthy, growing condition and also includes removing the weeds, litter and other debris along with retaining the finish grades in a neat uniform condition.

3.07 WARRANTY PERIOD AND FINAL ACCEPTANCE

A. Maintain plant materials from the time of planting until the plant materials are well established and are exhibiting a vigorous growth. Maintenance shall continue until the end of the Warranty Period as specified in Article 1.12 herein.
B. Inspection for Final Acceptance will be conducted at the end of the Warranty Period. Submit notice to the Resident Engineer requesting final inspection at least seven days prior to the anticipated inspection date.

C. Five days prior to the final inspection, apply granular form commercial fertilizer to all planting areas in accordance with the manufacturer’s application rates. Prevent the deposit of fertilizer on plant stems or leaves. Apply fertilizer only during favorable weather conditions to prevent dissipation by wind. Thoroughly water plants after fertilizer has been applied.

D. Prior to final inspection, thoroughly weed and clean planting areas.

E. Remove all tree stakes, vine stakes, and temporary landscape protection fencing one week prior to Inspection for Final Acceptance.

F. At the Inspection for Final Acceptance, the Resident Engineer will determine the condition of the plants and improvements. Acceptance of this Work will be contingent upon proper maintenance and the establishment of vigorous plant materials. Plans which are dead, unhealthy, or missing, whether by disease, neglect, vandalism, or any other reason, shall be replaced with the same species and sizes originally specified and following the same specifications for installation.

G. Provide plant replacements within two weeks after final inspection, and extend the Warranty Period for an additional 30 days after replacement planting has been accepted by the Resident Engineer. The Resident Engineer will then repeat the final inspection for the replaced plants at the end the extended Warranty Period.
CONTRACT SPECIFICATIONS

SECTION 33 01 00
OPERATION AND MAINTENANCE OF UTILITIES

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for maintenance, support, and protection of existing underground utilities as indicated.

1.02 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Submit to Resident Engineer a schedule of estimated shut-down times coordinated with utilities.
1. Obtain permission for shut-downs from utility owners and notify all interested parties, neighbors, utilities, and municipal and county authorities.
C. Submit plan or schematic of temporary water or sewer services to the Resident Engineer for review and coordination with the utility owners.
D. Submit to Resident Engineer a protection and access plan for existing 360 Networks and Comcast fiber optic and co-axial telecommunications facilities to be protected in place.
1. Obtain approval from utility owners or authorized agent and all interested parties within shared system(s) affected by Work. Approval shall be in the form of a written letter from the utility owner(s) representative indicating that proposed protection and access methods have been reviewed and design and construction methods are acceptable.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 EXAMINATION
A. Field-locate existing utilities by contacting the Utilities Underground Location Center at 1 (800) 424-5555.
1. For utility owners not covered by this telephone number, call the affected utility owners directly.
B. Ensure underground utilities are marked for identification by the affected utility companies before performing any excavation or other work close to any underground pipeline, conduit, duct, wire, or other structure.
1. Compare the field located utilities with the Contract Drawings. Notify Resident Engineer of discrepancies.
C. Renew field-locates over 360 Networks and Comcast fiber optic and co-axial telecommunications facilities within the Brooklyn Station Construction Limits periodically or as required for the duration of work to show location of buried facilities being protected in place and adjacent to excavation and staging areas.

3.02 CONSTRUCTION

A. Do not operate, disconnect, or shut down any part of the existing utilities and services, except by permission of authorities having jurisdiction.

B. Notify Resident Engineer and affected utilities a minimum of 2 and a maximum of 10 working days before digging.

C. Do not remove utilities until shut-down time can be kept to a minimum.

D. Do not remove an existing utility line or service until the replacement line, crossover, or capping is ready to be performed.

E. Record locations of cuts, caps and utility abandonment on as-built drawing.

3.03 PROTECTION

A. Maintain existing utilities not indicated for removal or abandonment and protect from damage.

B. Maintain sewer manholes, water valves, meters, fire hydrants, and utility vaults accessible and keep clear of blockages from equipment, debris or construction material.

C. When existing utility services occupy the same trench space as a new utility, excavate to fully expose such services. Protect such services and work around them during excavation and new utility installation operations.

1. In the event of conflict with other underground utilities, immediately notify the Resident Engineer.

D. Provide shoring, underpinning, and structural support for existing utility lines and structures that become suspended or otherwise unsupported because of adjacent excavation operations.

E. If underground utilities are damaged in any way, notify the Resident Engineer immediately for corrective action.

F. Contractor is responsible for all damage to existing utilities due to his operation and shall bear the cost to repair or replace the damaged utility.

G. Loading over 360 Networks and Comcast fiber optic and co-axial telecommunications facilities within the Brooklyn Station Construction Limits is limited to H20 load rating. Determine and design protection methods and requirements necessary to maintain integrity of system to remain in place. Maintain structural integrity of existing vaults, handholes, or other access structures associated with system. Access constraints will need to be confirmed with utility owner(s) representative.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for providing water service supply mains, modifications to existing water mains, and services in City of Seattle Right-of-Way as indicated.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 45 00, Quality Assurance/Quality Control.
2. Section 01 77 00, Closeout Procedures.
3. Section 01 78 23, Operation and Maintenance Data.
4. Section 01 78 39, Project Record Documents
5. Section 02 41 00, Demolition.
6. Section 31 23 19, Dewatering.
7. Section 31 23 33, Trenching and Backfilling.
8. Section 33 01 00, Operation and Maintenance of Utilities.

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. City of Seattle (COS):
   a. Standard Specifications for Road, Bridge and Municipal Construction
   b. Standard Plans for Municipal Construction

2. National Fire Protection Association (NFPA):
   a. NFPA 24, Standard for the Installation of Private Fire Service Mains and their Appurtenances

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Product Data: Include data on pipe, fittings, and appurtenances including manufacturer’s recommendations for pipe installation.
C. Lay plans for the pipeline construction. Include details for each connection to an existing main. The review of this submittal by the Resident Engineer, and municipal and county authorities does not relieve the Contractor of his responsibilities to any damage to existing utilities due to his operation in accordance with Section 33 01 00, Operation and Maintenance of Utilities.

D. General: Refer to Section 01 77 00, Closeout Procedures, and 01 78 23, Operation and Maintenance Data, for submittal requirements and procedures.

E. Record Documents: Show actual locations of piping mains, valves, connections, and depths of burial on the as-built drawings in accordance with Section 01 78 39, Project Record Documents for review.

F. Construction Work Plan: Submit a construction work plan in accordance with requirements of Section 01 45 00, Quality Control. An approved Construction Work Plan is a precondition for the Readiness Review Meeting.

1.04 QUALITY ASSURANCE

A. Provide piping materials that have been stamped or marked with the specified testing agency.

1.05 DELIVERY, STORAGE, AND HANDLING

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

B. Inspection: Inspect pipe before it is installed. Remove defective products from the Project Site.

1.06 PROJECT CONDITIONS

A. Sequencing and Scheduling: Include sequencing and scheduling information in the Construction Work Plan.

B. Operation of Seattle Public Utility (SPU) water system facilities by the Contractor is prohibited. In the event of an emergency contact the SPU Emergency Dispatch Center at 206-386-1800.

C. SPU limits the shutdowns to a maximum of three per main.

D. Supply all Work and material unless noted to be completed or provided by SPU. SPU will perform only the work as specified in these Contract Specifications and Contract Drawings.

E. SPU attendance at the Readiness Review Meeting is required.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Install only new materials for water distribution and transmission. Materials used for temporary water main and for temporary service connection purposes may be either new or previously used materials and are subject to the Resident Engineer’s inspection and approval prior to installation. Verify all direct and indirect drinking water
system components which come in contact with potable water have National Sanitation Foundation certification.


C. Pipe type and class is as indicated on the Contract Drawings.

D. Concrete Thrust Blocking: Constructed of Class 5 (1-1/2) concrete in accordance with COS Standard Specifications Section 5-05.3.

2.02 SOURCE QUALITY CONTROL

A. Water Main material to be used in City of Seattle Right-of-Way is subject to pre-installation taste and odor testing requirements in accordance with COS Standard Specifications Section 7-11.2(2).

PART 3 - EXECUTION

3.01 PREPARATION

A. Coordinate the installation of the water distribution system with other utilities to avoid conflicts.

B. Trench, Bed and Backfill as specified in Section 31 23 33, Trenching and Backfilling.

C. Provide safety systems for trench excavation as specified in Section 31 23 33, Trenching and Backfilling.

D. Trench dewatering as specified in Section 31 23 19 Dewatering. Continue trench dewatering until the ends of the pipe are sealed and provisions are made to prevent floating of the pipe. Prevent trench water or other deleterious materials from entering the pipe at any time.

E. Support and protect existing utilities as specified in Section 33 01 00, Operation and Maintenance of Utilities.

F. Abandon and remove existing water mains indicated for removal or abandonment as specified in Section 02 41 00, Demolition.

G. Pipe handling requirements in accordance with COS Standard Specification Section 7-11.3(2).

H. Protection:

1. Prevent water from entering trenches and excavations.

2. Other than chlorination chemicals and clean water, place nothing inside pipes and fittings.

3. Fit expansion plug into open end of pipe joints being laid. Allow plug to remain in-place when pipe laying is not in progress; remove plug when pipe laying is resumed. Protect mouth of pipe being laid in rock.

4. Protect exposed, installed pipe from damage and flooding.

5. Keep installed pipe clean until work has been accepted.
6. Protect pipe coatings from damage during storage and installation.

3.02 CONSTRUCTION

A. Comply with COS Standard Section 7-11.3.

B. If coated pipe is being used, provide a certified coating repair specialist to repair Contractor caused coating damage during construction of utilities and station. SPU will only repair damage to coating at time of SPU installation.

C. Support construction tasks performed by SPU as specified in Article 3.02D, herein, by providing shoring, dewatering, trenching, bedding, backfilling, thrust restraint and traffic control as necessary.

D. SPU crews will complete the following tasks associated with water mains:
   1. Operate existing valves.
   2. Drain, cut and cap water mains.
   3. SPU may install 4-inch to 6-inch taps at the caps for flushing the existing main depending on service location. These taps can then be used by the Contractor for flushing the new main, but the Contractor shall anticipate providing alternate methods for flushing the main.
   4. SPU will make all connections to existing active mains. When connecting new mains to existing mains, SPU will perform the work using Contractor furnished materials except where insulating couplings will be used. Insulating couplings will be furnished by SPU.
   5. Inspect the pipe material. Acceptance by the Resident Engineer shall be received prior to laying pipe.
   6. Perform quality assurance for the installations, and joint bonding welds to insure proper isolation and continuity. SPU will perform electrical continuity tests prior to pipe activation.
   7. Measure outside diameter of existing water mains at connection points on mains greater than 12-inches.
   8. Install or remove new water services.

3.03 FIELD QUALITY CONTROL

A. Testing of City of Seattle owned water mains and appurtenances shall be in accordance with the COS Standard Specifications.
   1. Hydrostatic pressure tests: COS Standard Specifications Section 7-11.3(11).
   2. Flushing and Disinfection: COS Standard Specifications Section 7-11.3(12).

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for providing the sanitary sewerage and combined
sewerage systems and connection to the existing sanitary and combined sewer systems
as indicated, temporary bypasses, utility support system, including but not limited to
pipes, maintenance holes, and the related cast iron and steel products required for
covers and maintenance holes steps and ladders.

B. Related Sections: The work of the following Sections is related to the work of this
Section. Other Sections, not referenced below, may also be related to the proper
performance of this work.

1. Section 01 45 00, Quality Assurance/Quality Control
2. Section 01 78 39, Project Record Documents
3. Section 02 41 00, Demolition
4. Section 31 23 19, Dewatering
5. Section 31 23 33, Trenching and Backfilling
6. Section 31 50 00, Excavation Support and Protection
7. Section 33 01 00, Operation and Maintenance of Utilities

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. City of Seattle (COS):
   a. Standard Specifications for Road, Bridge, and Municipal Construction
   b. Standard Plans for Municipal Construction

1.03 DEFINITIONS

A. Registered Side Sewer Contractor (RSSC)- Individual or firm that has been certified by
the City of Seattle Department of Planning and Development (DPD) to perform side
sewer/service drain utility construction within the public Right of Way.

B. Side Sewer – A privately owned and maintained pipe system which is designed to carry
sewage and/or stormwater runoff, surface water, foundation drainage and other
unpolluted water from a plumbing outlet, drain or other facilities to the public sewer
system.
C. Service Drain – A privately owned and maintained pipe system which is designed to carry stormwater runoff, surface water, foundation drainage, roof drainage, and other unpolluted water to the public sewer system or on-site infiltration system.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Certification: Submit a Manufacturer’s Certificate of Compliance, based on the manufacturer’s routine quality control tests showing that the material meets or exceeds the requirements in the reference COS Standard Specification or Standard Plan.

C. Submit to the Resident Engineer, for review, a written proposal for temporary sewer bypasses including a list of all equipment being used. Submit at least 10 Working Days in advance of scheduled work. The Resident Engineer’s review does not relieve the Contractor of its responsibilities or of any public liability for sewage spills.

D. Construction Work Plan: Submit a Construction Work Plan covering work according to the requirements of Section 01 45 00, Quality Assurance/Quality Control.

   1. Attend a readiness review meeting with representatives of Sound Transit and SPU to determine roles and responsibilities for the tasks and timing of the work to be incorporated into the construction work plan.

E. Structural Engineer’s Qualifications: For Contractor-designed utility support systems, submit qualifications of design engineer demonstrating similar recent design experience.

F. Record Documents: Show actual locations of piping mains, connections, and pipe inverts at maintenance holes on as-built drawings in accordance with Section 01 78 39, Project Record Documents, for review.

1.05 QUALITY ASSURANCE

A. Registered Side Sewer Contractor (RSSC): Side sewer and Service Drain construction or repair within the City Right of Way must be performed by a Registered Side Sewer Contractor (RSSC) and under an issued Side Sewer/Service Drain Permit from DPD. Coordinate with City of Seattle DPD for a list of registered side sewer contractors and/or procedures required to become a registered side sewer contractor.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General:

   1. Install only new materials. Materials used for temporary purposes may be either new or previously used materials and are subject to the Resident Engineer’s inspection and approval prior to installation.

B. Pipe, fittings, and joints: In accordance with COS Standard Specifications Section 9-05. Pipe type used for sanitary, combined and side sewers shall be the type indicated on the Contract Drawings.

C. Steel Casing Pipe

   1. Pipe: In accordance with COS Standard Specifications Section 9-30.2(14).
2. Seals and Spacers: In accordance with COS Standard Specifications Section 9-30.2(15).

D. Maintenance holes: In accordance with the COS Standard Plan number noted on the Contract Drawings. Materials in accordance with COS Standard Specifications Section 9-12 and 7-05.2.

E. Maintenance Hole Ring and Cover: COS Standard Specifications Section 9-12.8.


PART 3 - EXECUTION

3.01 PREPARATION

A. Notify Resident Engineer at least 20 days prior to beginning Work associated with the new or existing sanitary/combined sewer system. In addition to the Resident Engineer’s inspection, Seattle Public Utilities (SPU) will provide its own inspection services for the Work associated with the sanitary/combined sewer systems within City Right-of-Way. COS Department of Planning and Development (DPD) will inspect side sewer replacements and connections before reactivation. Provide side sewer as-built drawings to COS Department of Planning and Development in accordance with their standards.

B. Inspection: Inspect pipe before it is installed. Remove defective products from the Project Site.

3.02 CONSTRUCTION

A. Existing storm drainage systems shown on the Contract Drawings to be abandoned and/or removed shall be abandoned and/or removed in accordance with Section 02 41 00, Demolition.

B. Support and protect existing utilities as specified in Section 33 01 00, Operation and Maintenance of Utilities.

C. Excavate trenches, and place pipe bedding and backfill in accordance with Section 31 23 33, Trenching and Backfilling.

D. Maintenance hole bedding in accordance with COS Standard Specifications Section 7-05.3(1)B..

E. Dewatering: Keep excavations free of water during excavation, installation of pipeline, and placement of bedding and trench backfill. Control surface run-off so as to prevent entry or collection of water in excavations. Dewater excavations containing water per the requirements of Section 31 23 19, Dewatering.

F. Trench Safety and Support Systems: Where trench excavation is deeper than 4 feet, construct and maintain safety systems that meet the requirements of the Washington Administrative Code (WAC) Chapter 296-155 Part N. Comply with the requirements of Section 31 50 00, Excavation Support and Protection.

G. Monitor structurally supported sewer for movement throughout the project duration. Notify Resident Engineer and implement remedial measures if movement exceeds the maximum allowable amount specified in Article 1.06A.
H. Pipe installation and Jointing in accordance with COS Standard Specifications Section 7-17.3(2).

I. Install maintenance holes, re-channel existing maintenance holes, and make maintenance hole pipe connections in accordance with COS Standard Specifications Section 7-05.3.

J. Where indicated or necessary to provide uninterrupted sanitary sewer collection and conveyance, install temporary Sewer Bypass in accordance with the requirements of COS Standard Specifications Section 7-17.3(2)K.

K. When connecting new pipe to existing pipe where materials differ, use only new pipe having the same inside diameter as the existing. Match inverts, grade, and alignment. Connect joints between pipes with a mismatched wall thickness with a flexible gasketed coupling, adapter or coupling-adapter to make a watertight joint.

L. Leave side sewers and sewer mains uncovered until the Resident Engineer, DPD, and SPU have inspected and approved the work.

3.03 FIELD QUALITY CONTROL

A. Notice of Testing

1. Notify the Resident Engineer at least 2 Working Days before testing. Perform all testing in the presence of the Resident Engineer.

B. Cleaning and Testing:

1. Clean pipes and maintenance holes and perform testing as specified in the COS Standard Specifications Section 7-17.3(4).

2. Furnish, install, and operate pumps, gages, meters, and individual pipe connections for testing.

C. Television Inspection

1. Videotape the interior of all newly installed sewer pipes 6 inches through 48 inches to determine the acceptance of the Work. Perform television inspection work in accordance with the COS Standard Specifications Section 7-17.3(4).

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for providing the storm water drainage system and connection to storm drainage mains as indicated, including but not limited to drainage pipes, catch basins, drainage inlets, maintenance holes, and the related cast iron and steel products required for gratings, covers, and manhole steps and ladders.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 01 78 39, Project Record Documents
2. Section 02 41 00, Demolition
3. Section 31 23 19, Dewatering
4. Section 31 23 33, Trenching and Backfilling
5. Section 31 50 00, Excavation Support and Protection

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

1. City of Seattle (COS):
   a. Standard Specifications for Road, Bridge and Municipal Construction
   b. Standard Plans for Municipal Construction

1.03 DEFINITIONS

A. Registered Side Sewer Contractor (RSSC)- Individual or firm that has been certified by the City of Seattle Department of Planning and Development (DPD) to perform side sewer/ service drain utility construction within the public Right of Way.

B. Side Sewer – A privately owned and maintained pipe system which is designed to carry sewage and/or stormwater runoff, surface water, foundation drainage and other unpolluted water from a plumbing outlet, drain or other facilities to the public sewer system.

C. Service Drain – A privately owned and maintained pipe system which is designed to carry stormwater runoff, surface water, foundation drainage, roof drainage, and other unpolluted water to the public sewer or storm system or on-site infiltration system.
1.04 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Certification: Submit a Manufacturer’s Certificate of Compliance based on the manufacturer’s routine quality control tests showing that the material meets or exceeds the requirements in the referenced COS Standard Specification or Standard Plan.

C. Provide manufacturers data on all detention facilities and flow control structure materials.

D. Submit to the Resident Engineer, for review, a written proposal for temporary storm drainage bypasses including a list of all equipment being used. Submit at least 10 Working Days in advance of scheduled work. The Resident Engineer’s review does not relieve the Contractor of its responsibilities or of any public liability for damage caused by bypass failures.

E. Record Documents: Show actual locations of piping mains, connections, and pipe inverts at manholes on as-built drawings in accordance with Section 01 78 39, Project Record Documents, for review.

1.05 QUALITY ASSURANCE

A. Registered Side Sewer Contractor (RSSC): Side sewer and Service Drain construction or repair within the City Right of Way must be performed by a Registered Side Sewer Contractor (RSSC) and under an issued Side Sewer/Service Drain Permit from DPD. Coordinate with City of Seattle DPD for a list of registered side sewer contractors and/or procedures required to become a registered side sewer contractor.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General:
   1. Install only new materials. Materials used for temporary purposes may be either new or previously used materials and are subject to the Resident Engineer’s inspection and approval prior to installation.

B. Pipe, fittings, and joints: In accordance with the COS Standard Specifications Section 9-05. Pipe type used for storm drain conveyance shall be the type indicated on the contract Drawings.

C. Catch Basins, Inlets and Maintenance Holes: Use type as indicated on the Contract Drawings and in accordance with the COS Standard Plan number noted. Use materials in accordance with COS Standard Specifications Section 9-12 and 7-05.2.

D. Frame and Grate: In accordance with the COS Standard Specifications Section 9-12.

E. Maintenance Hole Steps, Handholds, and Ladders: Use type as indicated in the COS Standard Plan indicated and in accordance with the COS Standard Specifications Section 9-12.
PART 3 - EXECUTION

3.01 PREPARATION

A. Notify Resident Engineer at least 20 days prior to beginning work associated with the new or existing storm drainage system. In addition to the Resident Engineer’s inspection, SPU will provide its own inspection services for the Work associated with the storm drainage systems within COS Right-of-Way. COS Department of Planning and Development (DPD) will inspect service drain replacements and connections before reactivation. Provide service drain as-built drawings to DPD in accordance with their standards.

B. Inspection: Inspect pipe before it is installed. Remove defective products from the Project Site.

3.02 CONSTRUCTION

A. Existing storm sewer systems shown on the Contract Drawings to be abandoned and/or removed shall be abandoned and/or removed in accordance with Section 02 41 00, Demolition.

B. Excavate trenches, and place pipe bedding and backfill in accordance with to Section 31 23 33, Trenching and Backfilling.

C. Maintenance Hole, Catch Basin and Inlet bedding in accordance with COS Standard Specifications Section 7-05.3(1)B.

D. Where indicated or necessary to provide uninterrupted storm drainage collection and conveyance, install temporary storm drainage bypass in accordance with COS Standard Specifications Section 7-17.3(2)K.

E. Dewatering: Keep excavations free of water during excavation, installation of pipeline, and placement of bedding and trench backfill. Control surface run-off so as to prevent entry or collection of water in excavations. Dewater excavations containing water per the requirements of Section 31 23 19, Dewatering.

F. Trench Safety and Support Systems: Where trench excavation is deeper than 4 feet, construct and maintain safety systems that meet the requirements of the Washington Administrative Code (WAC) Chapter 296-155 Part N. Comply with the requirements of Section 31 50 00, Excavation Support and Protection.

G. Pipe installation and Jointing in accordance with COS Standard Specifications Section 7-17.3(2).

H. Install maintenance holes, re-channel existing maintenance holes and make maintenance hole pipe connections in accordance with COS Standard Specifications Section 7-05.3(1).

I. Install Catch Basins and Inlets, including pipe connections and adjustments to grade, in accordance with COS Standard Specifications Section 7-05.3(2).

3.03 FIELD QUALITY CONTROL

A. Notice of Testing
1. Notify the Resident Engineer at least 2 Working Days before testing. Perform all testing in the presence of the Resident Engineer.

B. Cleaning and Testing:

1. Clean pipes and maintenance holes and perform testing as specified in the COS Standard Specifications Section 7-17.3(4).

2. Furnish, install, and operate pumps, gages, meters, and individual pipe connections for testing.

3. TV Inspection: Videotape the interior of all newly installed storm pipes 6 inches through 48 inches to determine the acceptance of this portion of the Work. Perform television inspection work in accordance with the COS Standard Specifications Section 7-17.3(4).I.

C. Provide as-built surveys of all new storm drainage system.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes specifications for subsurface foundation drains at abutments, retaining walls, and building walls; permeable drainage panels; perforated pipe; and composite underdrains with piping, filter aggregate, and filter fabric as indicated.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 31 20 00, Earth Moving
2. Section 31 23 33, Trenching and Backfilling

1.02 REFERENCES

A. This Section incorporates by reference the latest revisions of the following documents.

   a. ASTM D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

   1. City of Seattle (COS):


      b. COS Standard Specifications for Road, Bridge, and Municipal Construction.

1.03 SUBMITTALS

A. Procedures: Section 01 33 00, Submittal Procedures.

B. Certification: Submit a Manufacturer’s Certificate of Compliance based on the manufacturer’s routine quality control tests showing that the material meets or exceeds the requirements in the referenced COS Standard Specification or Standard Plan.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Pipe and Fittings

1. Pipe Connection Requirements: To ensure continuous alignment of pipe, ends of pipe should be bell-and-spigot, grooved, ship lapped, or secured with couplings, collars, or other connection fittings.

2. Plastic Pipe:
a. Pipe:

1) Perforated PVC Pipe: Perforated polyvinyl chloride sub-surface drain (SSD) pipe and fittings shall be ASTM D 1785 Schedule 40 with rubber gasket joints. Pipe shall have slotted perforations 0.64 inch wide by 1.0 inch long and spaced 0.3 inches apart on center. Pipe size shall not exceed 8-inch diameter unless indicated otherwise in the drawings.

2) Solid Wall PVC Pipe: PVC pipe shall conform to the requirements of ASTM D 3034 for diameter sizes 4-inch through 15-inch. The minimum pipe stiffness shall be 46 lb/in/in.

B. Drainage Materials

1. Gravel Backfill for Drains: For aggregate drainage and filter material (permeable material) for filling trenches under, around, and over underdrains that is free from wood waste, organic material and conforms to the following gradings:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
<td>99-100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>80-100</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>0-40</td>
</tr>
<tr>
<td>No. 4</td>
<td>0-4</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-2</td>
</tr>
</tbody>
</table>


3. Preformed Permeable Drainage Liner: Prefabricated composite plastic drainage panels designed to provide hydrostatic relief for concrete foundation walls and retaining walls as indicated. Use panels of a button-pattern or other raised dimple feature which forms a drain core with flow channels at least 3/8 inch in thickness or clear depth, with geotextile filter fabric bonded to the raised pattern to prevent soil from entering the core channels and blocking the flow of water. Furnish drainage liner complete with installation accessories.

4. Drainage Matting: Use composite drainage matting for hydrostatic-relief drainage liner, consisting of a nylon or polypropylene core geomatrix of open, three-dimensional design, with a geotextile filter fabric bonded to the core to prevent soil from entering the core and blocking the flow of water. Ensure a minimum thickness or clear depth of ½ inch. Furnish drainage matting complete with installation accessories.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Pipe Installation

1. Excavate trenches for underdrain pipe as indicated. When not indicated, excavate to a width equal to the greater of 21 inches or the outside diameter of...
the pipe plus 12 inches and to a depth of 2 inches minimum below the grade established for the invert of the pipe. Coordinate with Section 31 20 00, Earth Moving, and Section 31 23 33, Trenching and Backfilling as applicable.

2. The geotextile shall be placed in the manner and at the locations as indicated on the Contract Drawings. The surface to receive the geotextile, and the trench into which the geotextile is to be placed, shall be free of obstructions and debris.

3. Fill space below the pipe invert with a layer of drainage aggregate as shown on the Contract Drawings.

4. Lay pipe to line and grade indicated with perforations down. Join sections in accordance with the manufacturer’s instructions. If pipe is of the bell-and-spigot type, lay bells in crosscuts cut in trench. Lay pipe with bell end uphill.

5. The gravel backfill shall be damp when placed and shall be tamped in 4-inch lifts to provide thorough compaction under and on each side of the pipe. Succeeding lifts of gravel shall be deposited in 8-inch lifts and be thoroughly compacted to the depth shown on the Contract Drawings.

6. Do not use rocks, bricks, broken concrete, or asphalt to give intermediate support to pipes. Do not leave stones larger than 2 inches or other hard objects in contact with the pipes.

7. If the geotextile becomes damaged, repair the torn or punctured section by placing a piece of geotextile of sufficient size to cover the damaged area including a minimum 12-inch overlap with all surrounding geotextile. In places where the trench width is less than 1 foot, the minimum overlap shall be the trench width.

B. Installation of Permeable Drainage Liner

1. Apply preformed permeable drainage liner or drainage matting to below-grade concrete walls as indicated in the Contract Drawings. Apply panels in accordance with the manufacturer's instructions, with filter fabric side out.

2. Shingle each course, overlapping panels in the direction of water flow. Provide side laps in accordance with manufacturer's instructions.

3. Provide interface with subsurface drainage piping at footings where indicated on the plans. Follow manufacturer's instructions for correct interface installation.

END OF SECTION
SECTION 34 41 13
TRAFFIC SIGNALS

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes specifications for modifying existing traffic signal system as indicated in the Contract Drawings or as directed by Resident Engineer.

1.02 REFERENCES
A. This Section incorporates by reference the latest revisions of the following documents.

1. City of Seattle (COS):
   a. COS Standard Specifications for Road, Bridge, and Municipal Construction
   b. COS Standard Plans for Municipal Construction

2. Federal Highway Administration (FHWA)

1.03 SUBMITTALS
A. Procedures: Section 01 33 00, Submittal Procedures.
B. Submit manufacturer's product data for all signal equipment to the Resident Engineer for acceptance.

PART 2 - PRODUCTS

A. Equipment

1. For traffic signals on streets and roadways that are owned or maintained by jurisdictions other than Sound Transit, the materials shall conform to the jurisdictional agency's standards and specifications.

PART 3 - EXECUTION

3.01 CONSTRUCTION
A. For traffic signals on streets and roadways that are owned or maintained by COS, perform the work described in this Section in accordance with the applicable requirements of the COS standard drawings and specifications.
B. Coordinate with City of Seattle for modification to traffic signal systems.

END OF SECTION